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ROTATING BAND TORQUES AND STRESSES ON AMCAWS 30MM COPPER BANDED PROJECTILES

Michael R. Kane

Rock Island Arsenal
Rock Island, Illinois

May 1975

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MICHAEL R. KANE

MAY 1975

FINAL REPORT

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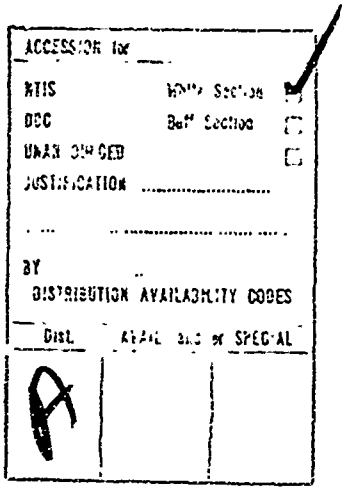

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This report details the study effort and testing conducted to design a more optimum rifling profile for the Advanced Medium Caliber Aircraft Weapon System (AMCAWS 30MM) ammunition. Several critical parameters such as bearing stress and torque have been identified and their importance to the ultimate survivability of the band assessed. These critical parameters have been incorporated into a preliminary model to predict the success or failure of a given band and barrel combination.

PRICES SUBJECT TO CHANGE

ABSTRACT

Quantitative values for the interaction of several candidate rifling profiles with the AMCAWS 30 ammunition were required so that a replacement for the original AMCAWS 30 barrel could be selected. This effort is primarily directed to that task.

A secondary effort was to document the process of deciding which candidate configurations would most probably be successful. There are several parameters arising out of this work designated as critical (such as bearing stress) and these critical parameters are included in a coarse model to predict success or failure of a given band and barrel combination.

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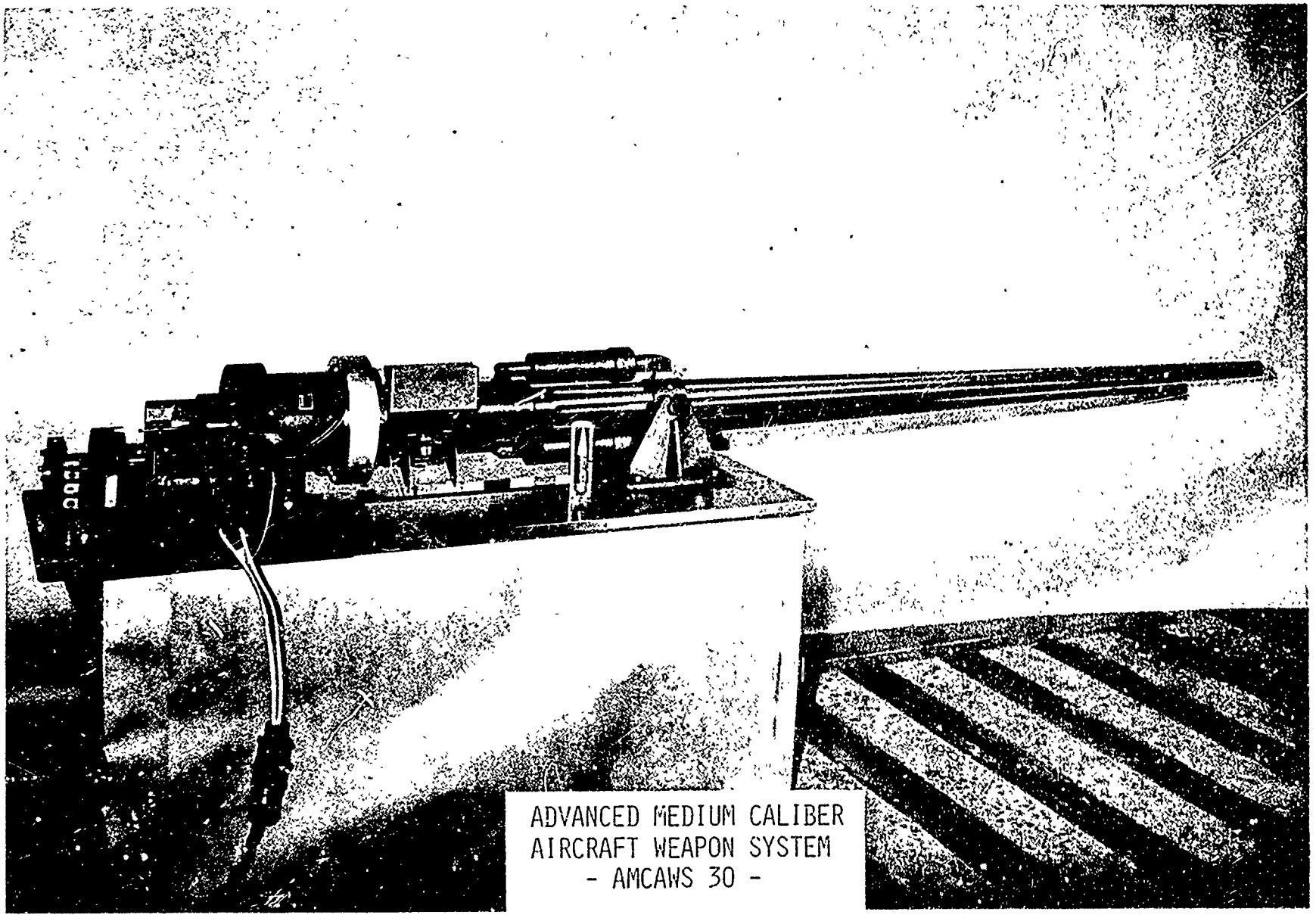

ADVANCED MEDIUM CALIBER
AIRCRAFT WEAPON SYSTEM
- AMCAWS 30 -

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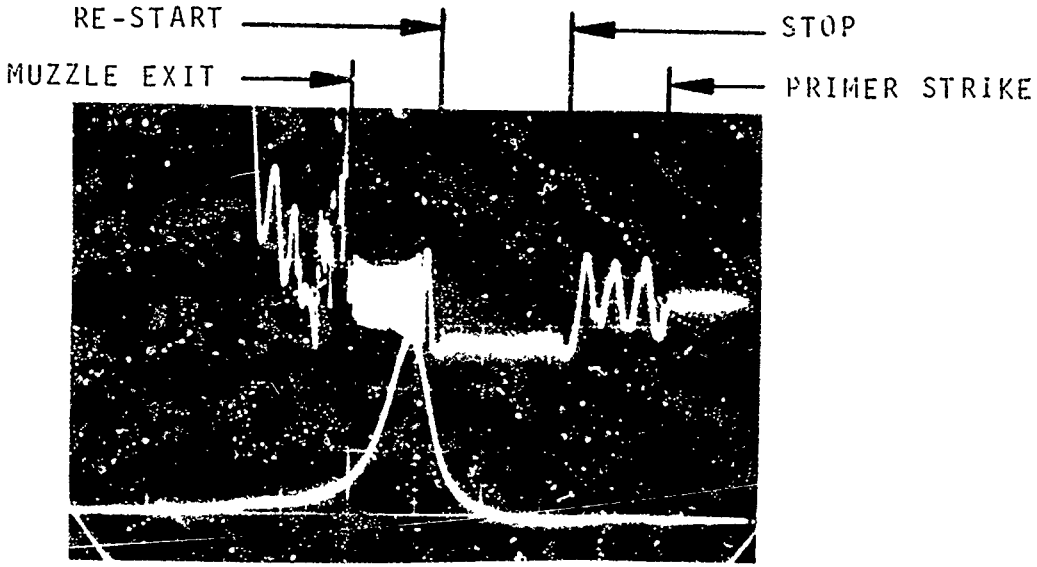
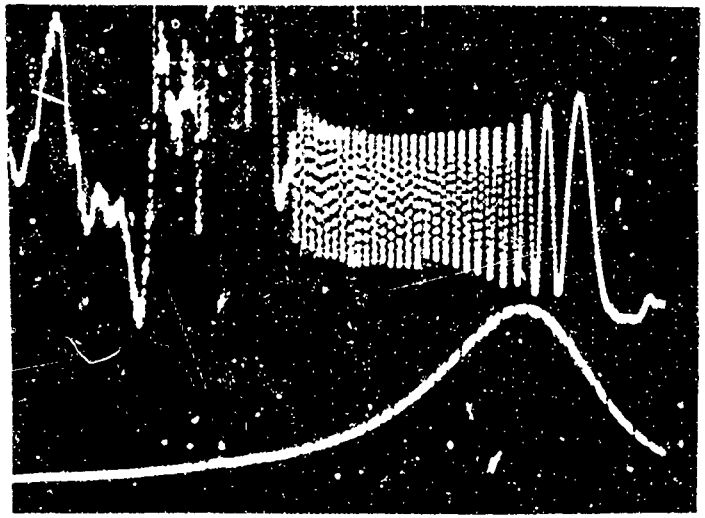
BACKGROUND

Quantitative values for torque and rotating band stresses for AMCAWS 30mm projectiles were required to meaningfully evaluate different types of barrel twists. Displacement, velocity down barrel, and chamber pressure at various time increments were used as input for a computer program (Appendix A, Barrel/Torque Comparisons) that calculated, as its principle output, torque, bearing stress, and shear stress at the rotating band for each time increment. The interior ballistics data was based on an interferometer trace obtained at the Hercules, Inc., test range in Magna, Utah. This trace, Figure 1, is of excellent quality and is one of the best obtained. The particular round examined had essentially nominal chamber pressure, action time, and muzzle velocity.

Six barrels with different twist functions were compared in the program using the same interior ballistic parameters. The barrel types were: (1) current Rock Island Arsenal produced barrels (RIA); (2) current Hercules barrel (Hercules); (3) constant twist barrel and exponential gain twist barrels with exponents of (4) N = 1.6, (5) N = 1.8, and (6) N = 2.0. These barrels are fully described in the description of barrels.

The work to obtain torque and stress values was started as part of a routine investigation to complement the AMCAWS 30mm development work, but the work pace was accelerated when in-flight pictures indicated some stripping of bands (but no instability) on some rounds





TIME SCALE: 2 MSEC PER CM
PRESSURE: 20K PER CM
MICROWAVE CALIBRATION: 2.567 INCHES PER CYCLE

1.A.

TIME SCALE: 0.5 MSEC PER CM
PRESSURE: 20K PER CM
MICROWAVE CALIBRATION: 2.567 INCHES PER CYCLE

1.B.

FIGURE 1. MICROWAVE DISTANCE VS TIME AND PRESSURE VS TIME FOR AMC 30 FIRING NO. A-421

13 JULY 1973

fired in the RIA barrels. This stripping was first noticed in June 1973. Work was begun on this effort in late August 1973, at which time the RIA and Hercules barrels were in use. The decision to fabricate a constant twist barrel and an N = 1.6 twist barrel was made in September 1973 and these two barrels became available at Rock Island in June 1974. The firing tests were conducted in late October 1974. The computer program itself was extensively rewritten after July 1974 to make use of a CALCOMP graphics system that became operational in Rodman Laboratory during that month.

DESCRIPTION OF BARRELS

1. RIA BARREL. This is an 85-inch barrel made to Rock Island Arsenal Print 74D40070. This barrel has a 1.0 inch throat, free run to 4.0 inches, gain twist to 73.25 inches and constant twist at an 8°58' exit angle to the muzzle. The equation for the twist was obtained by fitting a curve to the x-y layout coordinates. The equation is $y = B_0 + B_1 (X-4.0) + B_2 (X-4.0)^2 + B_3 (X-4.0)^3 + B_4 (X-4.0)^4$. The coefficients are listed in the Barrel/Torque Comparisons program in subroutine AAMC 30 (Appendix A).

2. HERCULES. This is an 89-inch barrel. This barrel has a 1.0 inch throat and gain twist to the muzzle at an 8°5' exit angle. The barrel has no constant twist exit portion. The equation of the rifling layout is:

$$Y = .01008 (X-1.0)^{1.5}$$

3. CONSTANT. This is an 85-inch barrel with a 1.0 inch throat and constant twist throughout the remaining barrel length. The rifling angle is 8°58'.

4. N = 1.6. This is an 85-inch barrel. This barrel has a 1.0 inch throat, gain twist to 81.0 inches and constant twist to the muzzle at an 8°58' exit angle. The equation of the rifling is:

$$Y = .00641042 (X + 14.1582)^{1.6}$$

The gain twist function in this barrel starts with a rifling angle of 3°0' at X = 1.0 inch and gains to 8°58' at X = 81.0 inches.

5. N = 1.8. This is identical to barrel N = 1.6 except the gain portion of rifling equation is:

$$Y = .00208633\ (X + 25.9727)^{1.8}$$

6. N = 2.0. This is identical to barrel N = 1.6 except the gain portion of rifling equation is:

$$Y = .000658627\ (X + 38.78559)^{2.0}$$

All the barrels described have 20 lands. The depth of groove for the RIA barrel is .019 inches. The groove depth for the remaining barrels is .025 inches.

The notation N = _._, refers to the type of barrel that has an initial rifling angle of 3° with an exponential gain twist portion and a constant twist exit portion. N = _._ barrels include the N = 1.6, N = 1.8 and N = 2.0 barrels.

INTERIOR BALLISTICS PERFORMANCE

The AMCAWS 30mm round (Figure 2) is a fully telescoped, cased-consolidated round that is currently designed to operate in a stop mode. The primer is struck, which ignites a 45-grain booster charge. The ignition of the booster debullets the projectile and forces it into the bore where, after a total travel of generally less than 5 inches past the barrel face, the projectile stops (thus a stop mode). The hot gas from the booster also acts as an igniter for the 3000 grain consolidated main charge, which causes the large pressure rise that drives the projectile out the muzzle at about 3600 ft/sec.

The set of interior ballistics data used for the barrel comparisons was obtained by considering the round ballistics to be composed of three separate segments: (1) the velocity, position, chamber pressure, and time data points after primer strike and up to the projectile stopping in the bore; (2) the data points between stop and restart; and (3) the data points after restart to muzzle exit. These three regions and the times of occurrence are illustrated in Figure 1.a., which is an interferometer trace of a firing conducted at Hercules, Inc., Magna, Utah.

Figure 1.a. shows the total event with time progressing from right to left at two milliseconds per centimeter. The microwave pulses show that initial movement of the telescoped projectile accounted for

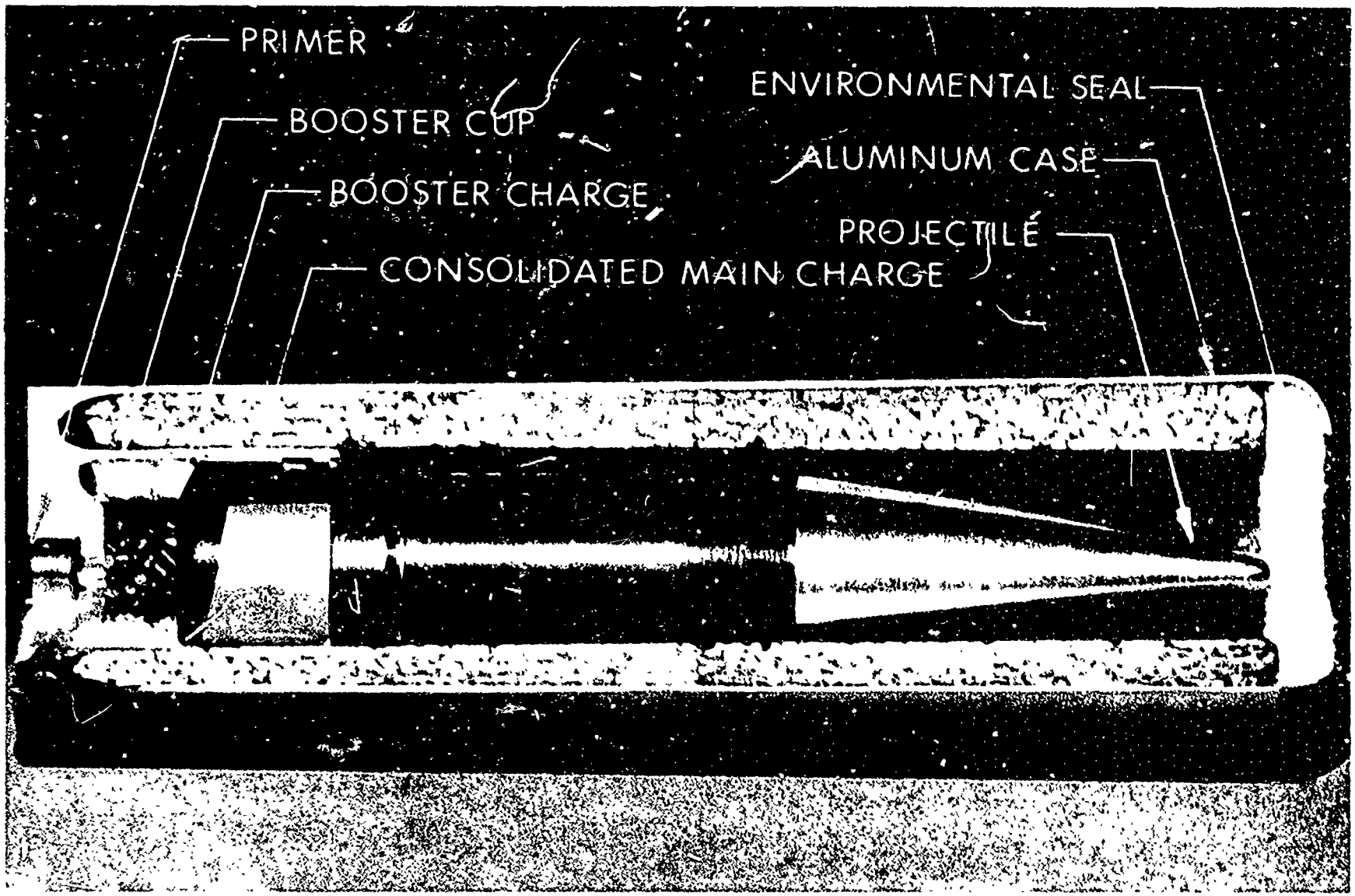


FIGURE 2. AMCAWS 30MM ROUND

about 3-1/4 cycles in about 3 milliseconds. The calibration factor for this firing is 2.567 inches per cycle, thus the 3-1/4 cycles indicates that the nose of the projectile moved approximately 8.34 inches before stopping. Using values of 4.4 inches between the projectile nose (point of reflection of microwave beam) and the center of the rotating band and a starting position of .25 inches between the nose and the start of the barrel, the position of the rotating band when stopped is then 3.69 inches from the barrel face. The microwave pulses show the projectile to be stopped for approximately 4 milliseconds (2 cm on the trace) and then the projectile accelerates rapidly with the rise in chamber pressure. The rapid acceleration is seen more clearly in Figure 1.b., where an expanded time scale is shown.

The most important of the three interior ballistics segments, as far as sustained high torque seen by the rotating band is concerned, is the restart to muzzle exit portion. Fortunately, the time scale, when expanded (Figure 1.b.), has excellent resolution of the traces and can be reduced to the graph of Figure 3. Corresponding chamber pressure for each time is also obtained. A smooth curve is fit through the raw velocity data points and the equation of this curve generated. This equation can be differentiated to yield projectile acceleration down the tube for this segment.

The second segment (between stop and restart) has a relatively constant pressure and no projectile movement. Pressure, velocity,

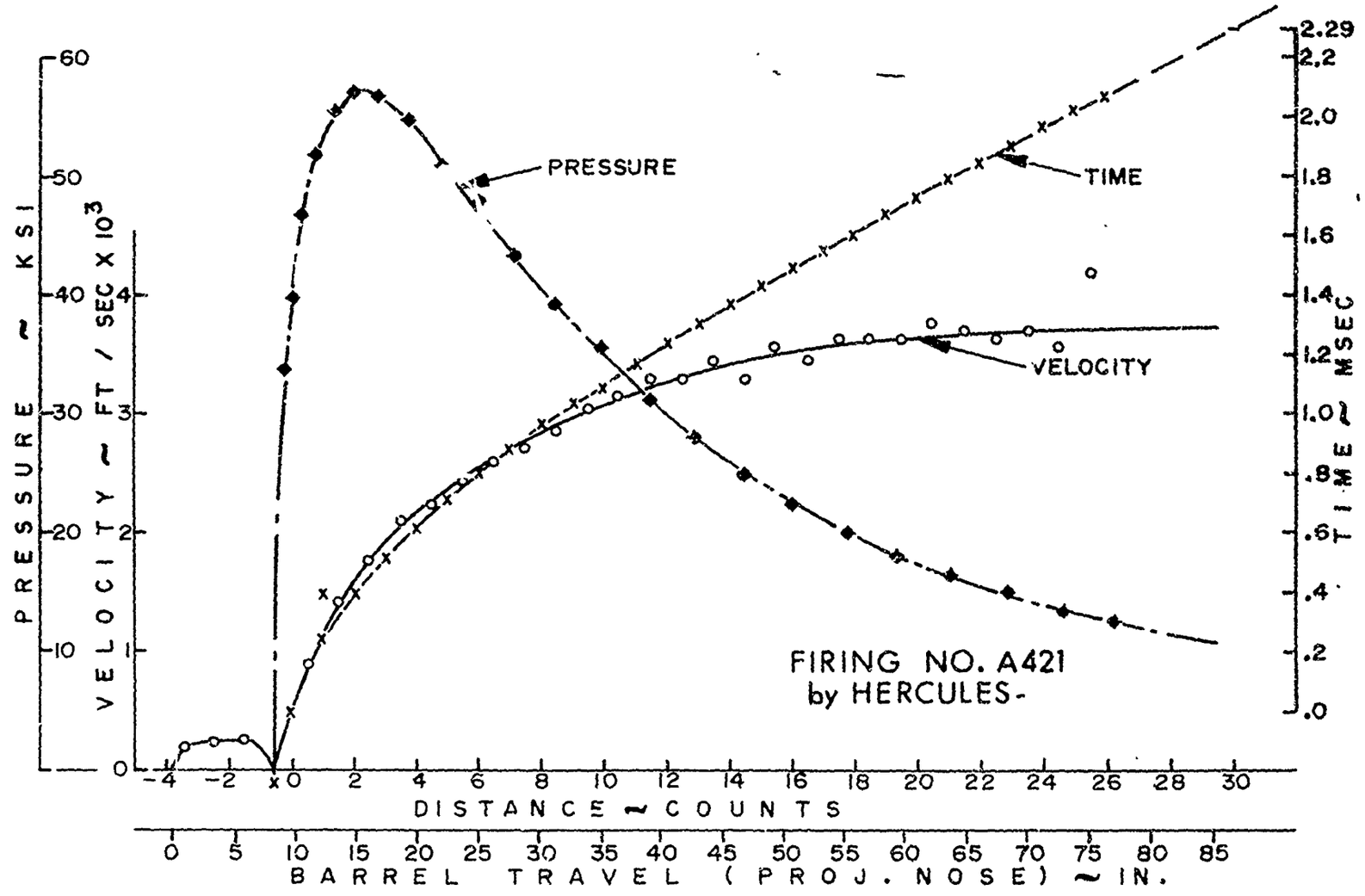


FIGURE 3. VELOCITY, PRESSURE AND TIME VS BARREL POSITION, AMCAWS 30 FIRING NO. A421

position, acceleration and time data points are easily generated for this segment.

The first segment (primer strike to stop) is the hardest to resolve to the point where ballistic data points can be obtained that have a high degree of confidence. The overall picture (Figure 1.a.) gives the time of occurrence and indicates some approximate values of position and time. The values obtained from the trace and other work done with booster performance enables "data" to be manufactured which should reasonably duplicate the performance of the round in the first segment. This data does not have as high a degree of confidence as the third segment data because of the poorer resolution, but torques are only seen in this segment for an extremely short time and projectile velocity is low, so possible inaccuracies in this segment of the data are not too important to the conclusions of this report.

Data representing the second segment was used as input for data generating program (Appendix B, AMCAWS 30mm Interior Ballistics). The program chiefly uses equations generated for position, velocity, and chamber pressure as functions of time for segments one and three and uses these equations to calculate the IB parameters for these segments. The program then links the data of the three ballistic segments and punches a complete data deck. This deck represents the nominal interior ballistics of the AMCAWS 30mm round, from primer strike to muzzle exit. The interior ballistics of the round are illustrated in

Figures 4 and 5. One result of obtaining acceleration by differentiating the smoothed velocity data can be seen by observing the slight discrepancy between the chamber pressure shape and the shape of the curve for acceleration. This problem is caused by an inability to more accurately resolve the original interferometer trace. The acceleration curve should be very close to the 'correct' curve and it is not felt that the results of the computer program are in any way unduly compromised.

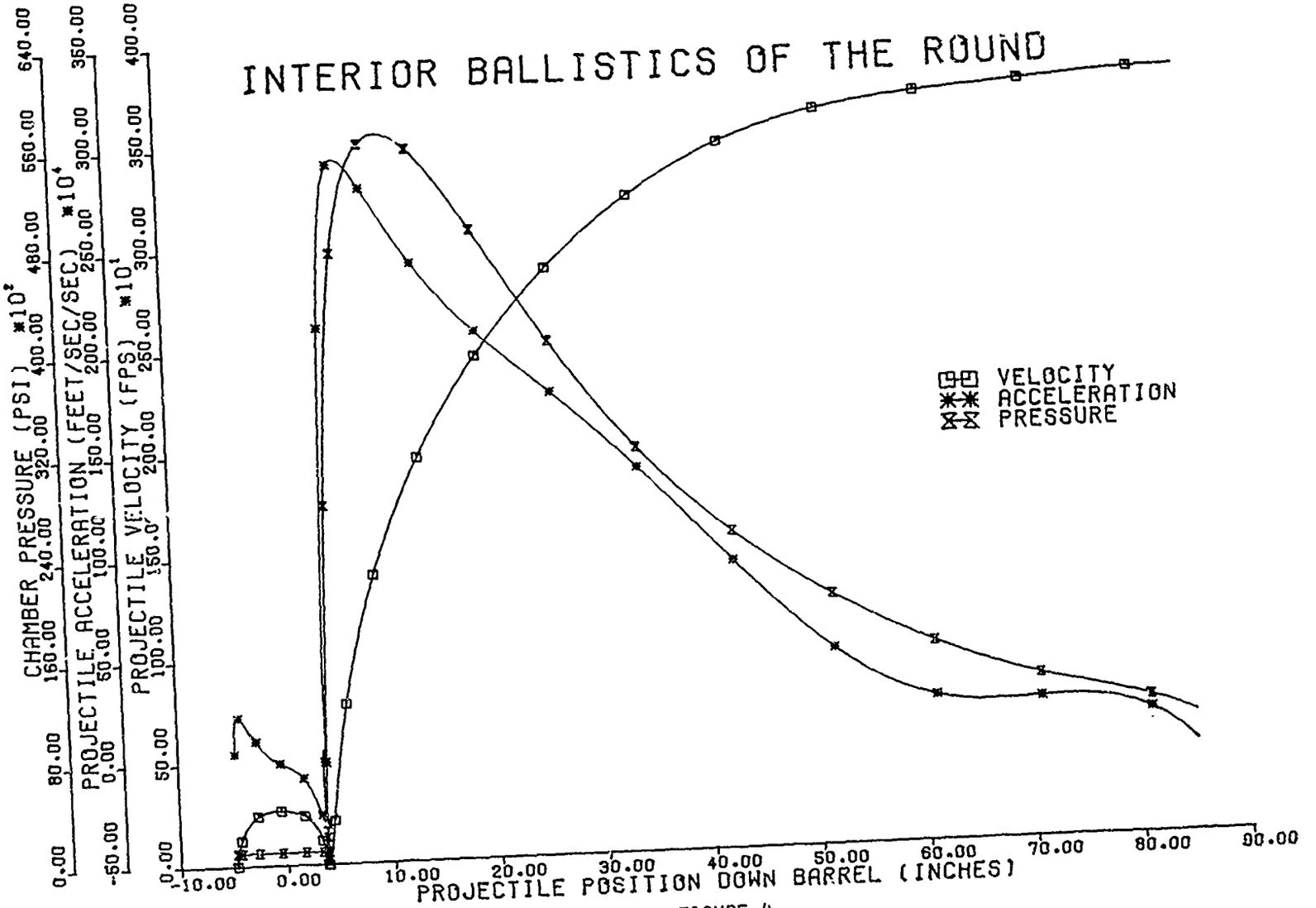

INTERIOR BALLISTICS OF THE ROUND
CHAMBER PRESSURE (PSI) *10²
PROJECTILE ACCELERATION (FEET/SEC/SEC) *10⁴
PROJECTILE VELOCITY (FPS) *10¹
VELOCITY
ACCELERATION
PRESSURE
PROJECTILE POSITION DOWN BARREL (INCHES)

FIGURE 4

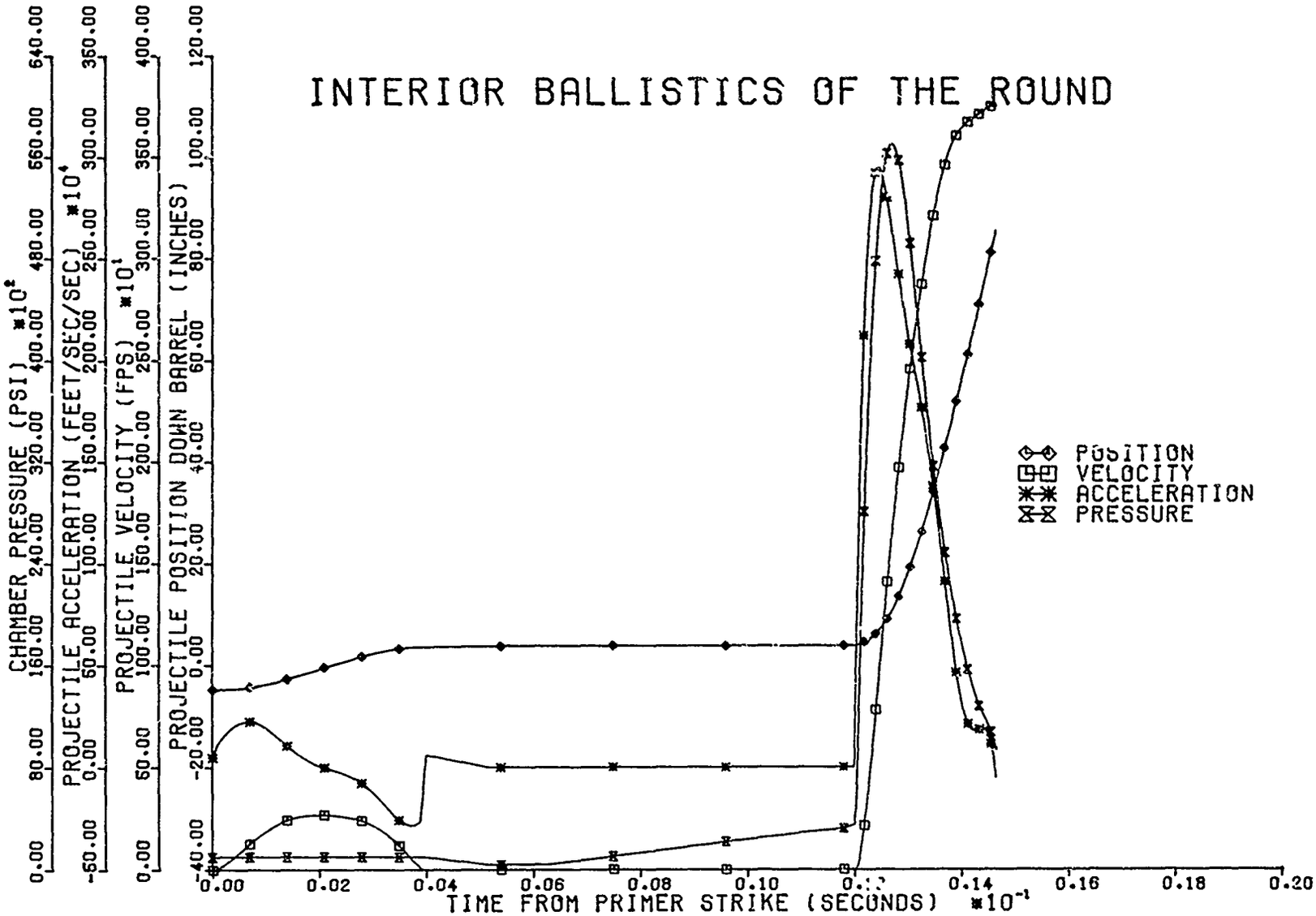

INTERIOR BALLISTICS OF THE ROUND
CHAMBER PRESSURE (PSI) *10²
PROJECTILE ACCELERATION (FEET/SEC/SEC) *10⁴
PROJECTILE VELOCITY (FPS) *10¹
PROJECTILE POSITION DOWN BARREL (INCHES)
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹
POSITION
VELOCITY
ACCELERATION
PRESSURE

FIGURE 5

DEVELOPMENT OF TORQUE AND STRESS EQUATIONS

Figure 6 shows a rifling curve in the gun tube. Y is the arc length subtended by Θ, R is the nominal 30MM radius (.59175 inches) and X is the distance down the bore the rotating band has traveled. Assuming no shear in the rotating band, the rotation of the projectile after traveling X inches is Θ.

Torque and stress relationships will be obtained using the equation,

$$\text{Torque} = I_{polar} \times \frac{d^2\Theta}{dt^2}$$

therefore $\frac{d^2\Theta}{dt^2}$ is a quantity of much interest. From Figure 6,

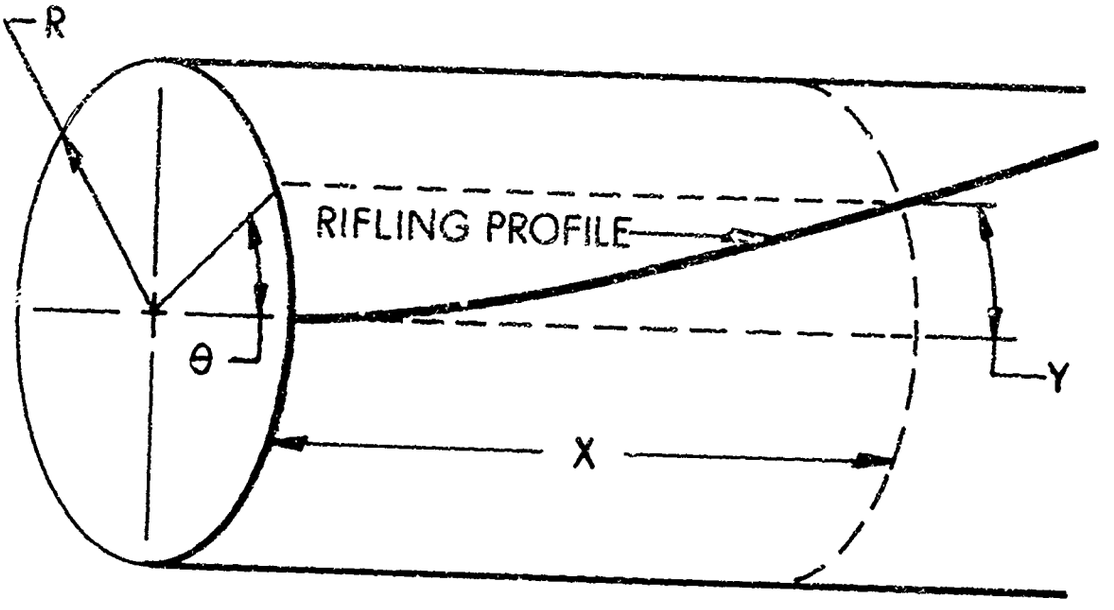
$$R\Theta = Y$$

$$\frac{d(R\Theta)}{dt} = R\frac{d\Theta}{dt} = \frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$$

but,

$\frac{dx}{dt}$ = velocity of projectile down the tube, thus

$\frac{d\Theta}{dt} = \frac{1}{R}\left[\frac{dy}{dx}\ (\text{velocity})\right]$. Differentiating again



R - NOMINAL 30MM RADIUS
X - DISPLACEMENT
θ - ANGLE OF ROTATION
Y - ARC LENGTH SUBTENDED BY θ

RIFLING CURVE LAYOUT

FIGURE 6

$$\frac{d}{dt}\left[R\,\frac{d\Theta}{dt}\right] = \frac{d}{dt}\left[\frac{dy}{dx}\;\frac{dx}{dt}\right] = \left[\frac{dy}{dx}\;\frac{d^2x}{dt^2} + \frac{dx}{dt}\;\frac{d^2y}{dx^2}\;\frac{dx}{dt}\right]$$

$$= \left[\frac{dy}{dx}\;\frac{d^2x}{dt^2} + \frac{dx}{dt}^2\;\frac{d^2y}{dx^2}\right]$$

However,

$\frac{d^2x}{dt^2}$ = acceleration of projectile down tube, thus

$$\frac{d^2\Theta}{dt^2} = \frac{1}{R}\left[\frac{dy}{dx}\;(\text{acceleration}) + \frac{d^2y}{dx^2}\;(\text{velocity})^2\right]$$

Summarizing,

$$\Theta = \frac{1}{R}\left[Y\right]$$

$$\dot{\theta} = \frac{1}{R}\left[\frac{dy}{dx}\;\text{velocity}\right]$$

$$\ddot{\theta} = \frac{1}{R}\left[\frac{dy}{dx}\;\text{acceleration} + \frac{d^2y}{dx^2}\;(\text{velocity})^2\right]$$

Values for velocity and acceleration (as discussed in the INTERIOR BALLISTICS portion of this report) are available to the BARREL/TORQUE COMPARISONS program so that with the proper equation of the rifling for the barrel under consideration $\ddot{\theta}$ can be determined for any position or time.

Given the values for $\ddot{\theta}$, the other calculations are quite straightforward. Torque is obtained from the relationship

$$T = I_{polar}\ddot{\theta}$$

Torque, however, can be considered to be the result of a distributed force acting at the rotating band (nominal radius to rotating band is .59175 inches). The total force acting to create the torque is then

$$\Sigma F = T/R.$$

The area upon which this total force acts is, of course, the bearing faces of the engraved rotating band (Figure 7). The bearing stress is then

$$S_{bearing} = \Sigma F/\Sigma \text{ (bearing face area)}.$$

Likewise, the shearing stress on the band is then

$$S_{shear} = \Sigma F/\Sigma \text{ (shearing face area)}.$$

The sketch of Figure 7.a. shows the dimensions of a rotating band that was fired through a RIA barrel. The nominal groove depth of the RIA barrel is .019 inches so the summation of bearing face areas is .137 square inches. The Hercules barrel has a groove depth of .025 inches so its total bearing face area is .180 square inches. The total shear for the recovered projectile is .677 square inches.

DIMENSIONS

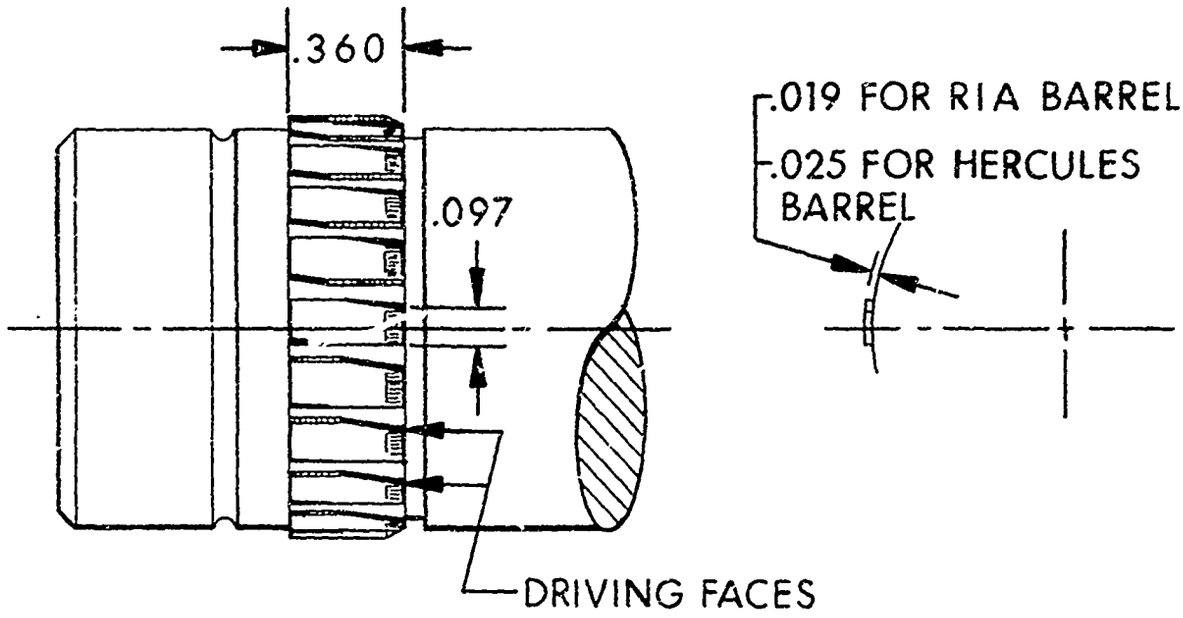


FIGURE 7-A

ROTATING BAND SEGMENT

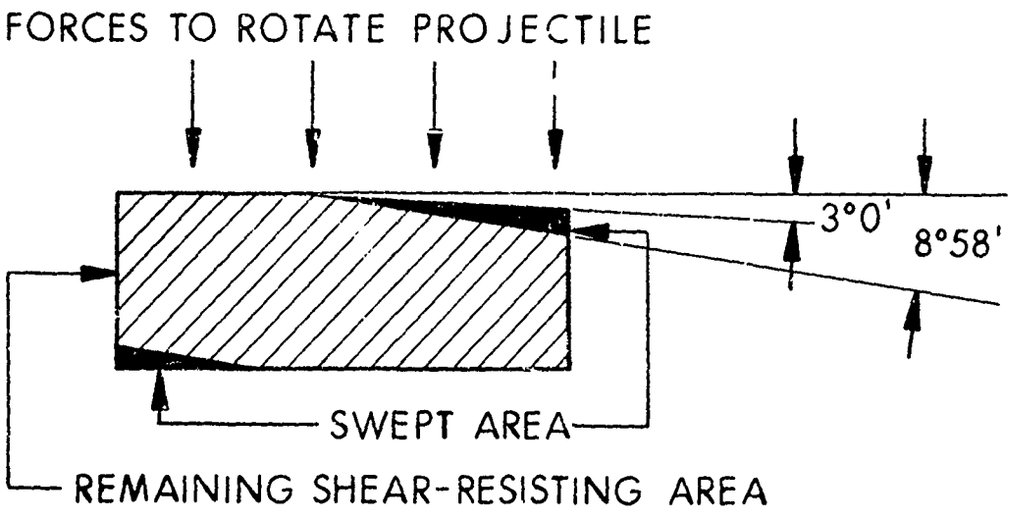


FIGURE 7-B

OBSERVATIONS

There are any number of ways to interpret the numbers generated by the Barrel/Torque Comparisons computer program. There is also a high probability that any arbitrary interpretation and the corresponding conclusions as to predicting the success of the rotating band and barrel twist combination will be incorrect. The most important aspect that must be considered when evaluating the program results and making useful conclusions is the actual mechanism of rotating band failure that may occur.

Factors which may affect the ultimate success of a rotating band probably include a combination of factors such as (1) peak torques, (2) time duration of high torques, (3) driving edge pressure, (4) area remaining that resists shear, (5) band properties, (6) band melting, (7) barrel wear, and probably several other considerations.

The way in which these named and unnamed factors interact in the AMCAWS 30mm system to determine the final condition of the rotating band is, of course, the mechanism of rotating band failure. Determining the actual mechanisms of failure for the rotating bands of high performance ammunition is certainly a large scale test and research program that is far beyond the scope of this report. A literature search (unclassified) has been relatively unsuccessful in uncovering work that specifically deals with copper rotating band failure in small to medium

calibers. What is primarily the scope of this report is to provide a basis for selecting a replacement for the RIA twist barrels. Hopefully, with the fabrication and availability of RIA, N = 1.6, constant twist, and Hercules barrels, some correlation between the program results and actual firing test results can be developed. Developing such a correlation is a secondary portion of the scope of this report. If a correlation between actual results and some combination of numbers generated by the program can be found, it might be able to act as a quick and coarse means of evaluating barrel twist suitability for future or proposed high performance medium caliber weapon systems. The remainder of this report is written with that in mind. Some general discussion of barrel twists is then pertinent.

Any gain twist barrel is sensitive to the interior ballistics of the round. A round with slightly delayed peak pressure and thus delayed peak acceleration will be in a steeper portion of the gain twist curve and therefore higher than optimum torques develop. The present RIA barrel configuration has good torque characteristics for certain ballistic performance, unfortunately they are not similar to the performance of the current AMCAWS 30mm round.

Another problem common to gain twist barrels is the rifling angle sweeping action that reduces the shear area of the rotating band and continually puts high bearing loads on the forward portion of the band. This sweep is due to the constantly increasing rifling angle

in the gain portion of the barrel and as illustrated in sketch of Figure 7.b. The 3° initial twist for the N = _._ barrels was chosen because it was felt the almost 9° sweep on the RIA barrel was one of the major contributing factors to the failure of that barrel-rotating band combination. The fact that there is evidence of band stripping on the RIA barrel but no in-flight instability of the round tends to indicate the bands finally do strip after the round has attained sufficient spin to be stable. The higher spin rates necessary to stabilize the round can only be imparted to the round in the muzzle portion of the gun tube where the rifling angles are high. Thus, it appears the bands do strip in the muzzle region of the RIA barrel, after experiencing most of the 8°58' sweep.

The behavior of gain twist barrels, especially with regard to increasing exponents, can be seen in Figures 8 and 9. The peak torque values occur later with increasing exponents. The peak values are less with increasing exponents but the curve itself is much flatter. These effects are particularly noticeable in the torque vs. displacement curve, Figure 8.

The barrel that appears most attractive, of the gain twist barrels considered, is the N = 1.6 barrel. A constant twist exit portion is desired so that the torque is low at projectile exit. Four to five calibers of constant twist should be long enough to minimize any pertubations that might be caused by a high torque at exit. The

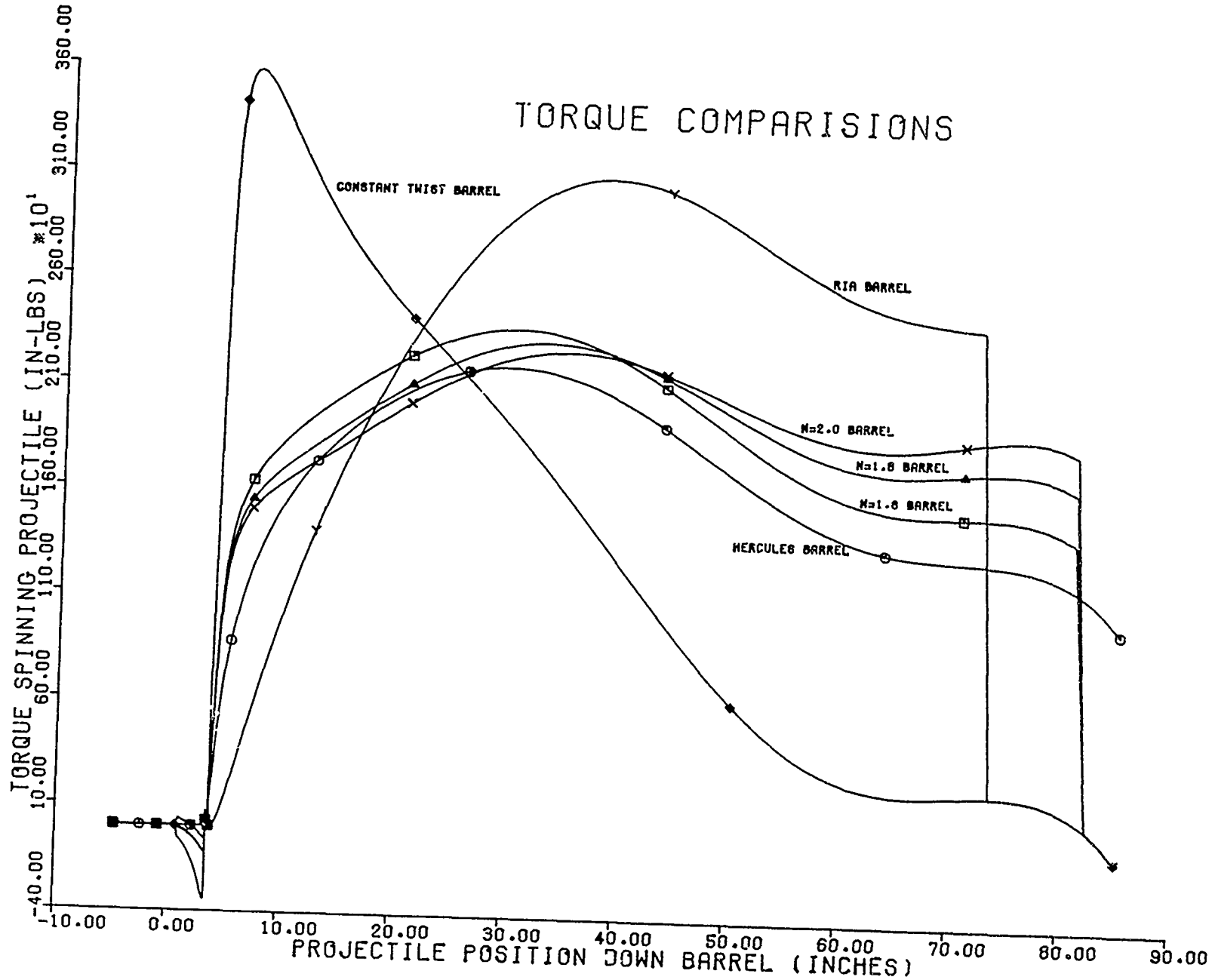

TORQUE COMPARISIONS
CONSTANT TWIST BARREL
RIA BARREL
M=2.0 BARREL
M=1.8 BARREL
M=1.6 BARREL
HERCULES BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
360.00
310.00
260.00
210.00
160.00
110.00
60.00
10.00
-40.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)

FIGURE 8

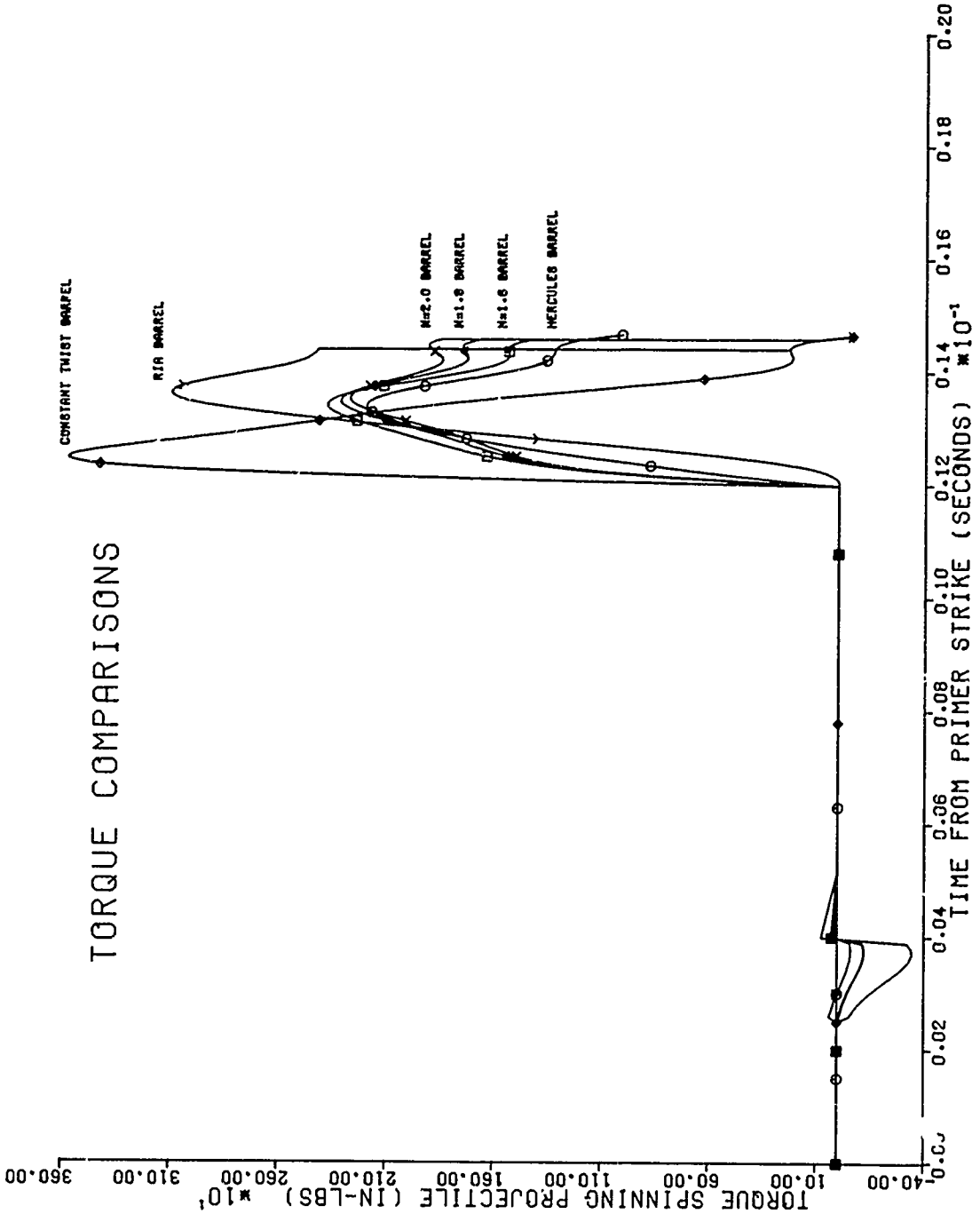

TORQUE COMPARISONS
CONSTANT TWIST BARREL
RIA BARREL
M=2.0 BARREL
M=1.8 BARREL
M=1.6 BARREL
HERCULES BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹
40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20

FIGURE 9

N = 1.6 barrel has a slightly higher peak torque than the N = 1.8 or the N = 2.0 barrels, but it should handle slight round-to-round ballistic changes better.

Constant twist barrels are, compared to gain twist, relatively insensitive to interior ballistic changes. Constant twist causes none of the sweeping action found in gain twist barrels, so the shear area is always at a maximum for any given exit angle. Unfortunately, constant twist barrels exhibit higher torques than their gain twist counterparts. The time duration for the peak torque region is correspondingly less. This is shown by the sharper peak on the torque vs. displacement curve (Figure 8).

Constant twist barrels can also be fabricated with more manufacturing techniques than can gain twist barrels. Broaching, swaging, or hammer forging (which are possible only with constant twist) are generally cheaper than hook tooling or the more exotic ECM techniques, especially in a quantity production environment. The barrels used to date in the AMCAWS 30 program have all been hook tooled.

FIRING TEST

Completion of the fabrication of an N = 1.6 and a constant twist barrel, combined with the availability of an RIA twist barrel, allowed a firing test to be conducted that was designed to evaluate the three band/barrel combinations. A series of 28 shots with basic Mann barrel instrumentation (chamber pressure, round action time, velocity) was fired with down-range photographic equipment set up (Figure 10) so that in-flight pictures of the fired AMCAWS 30 rounds could be obtained. The firing data for these rounds is listed in Table 1. The ammunition used is Lot X05. All three barrels had less than 20 rounds each fired through them when the test began.

The pictures obtained were of excellent clarity. The three pictures chosen for each barrel for inclusion in this report are very representative of all the pictures taken.

Rounds 63, 68, and 72 are rounds fired through the RIA twist barrel. These pictures show the bands completely stripped. The rounds are stable as shown in the pictures. Rounds fired through RIA twist barrels have always targeted well. This reaffirms the belief that these bands stripped only after a large enough spin rate was obtained for the round to be stable.

Rounds 74, 75, and 80 are rounds fired through the constant twist barrel. The bands on these projectiles are in excellent condition.

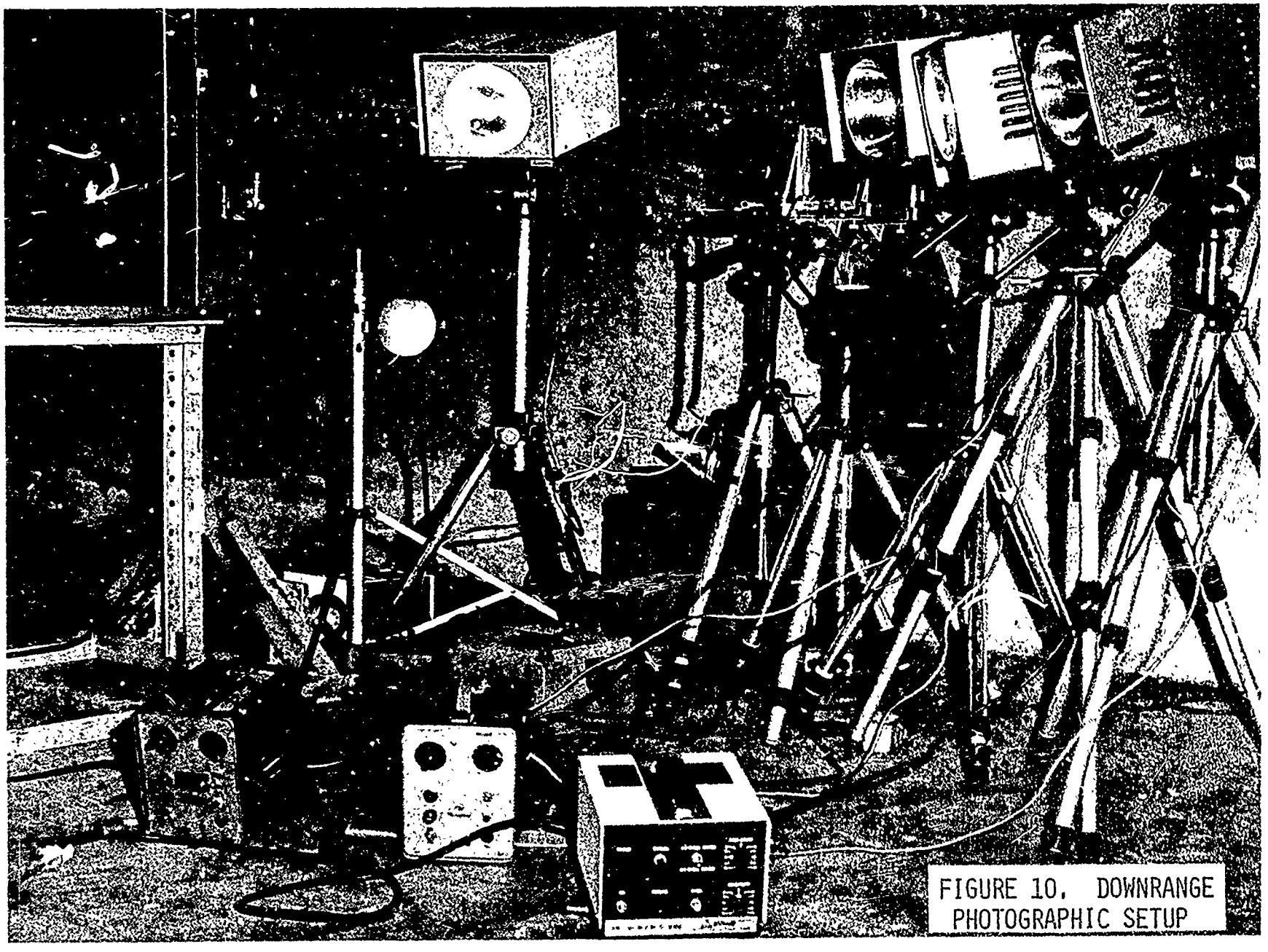
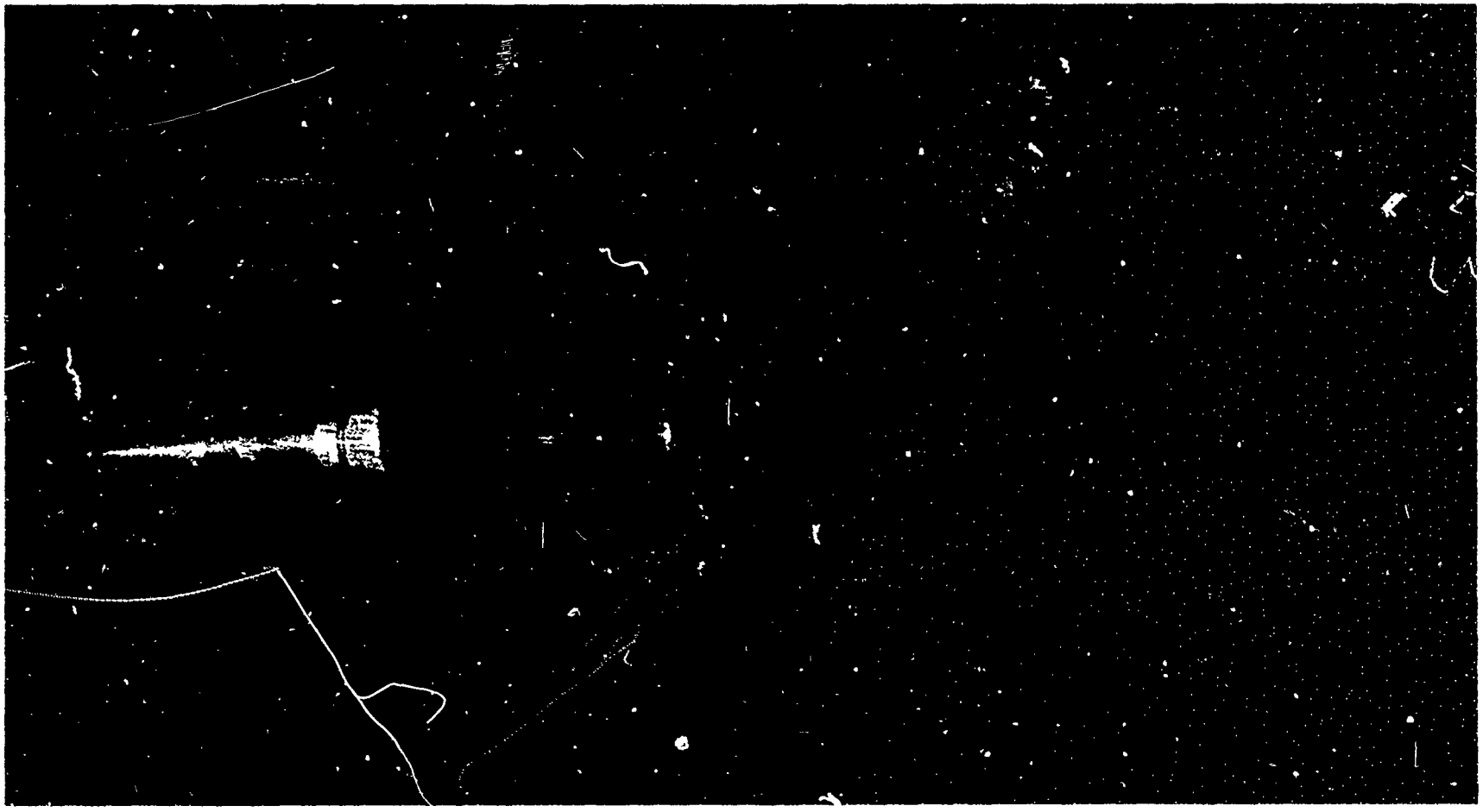


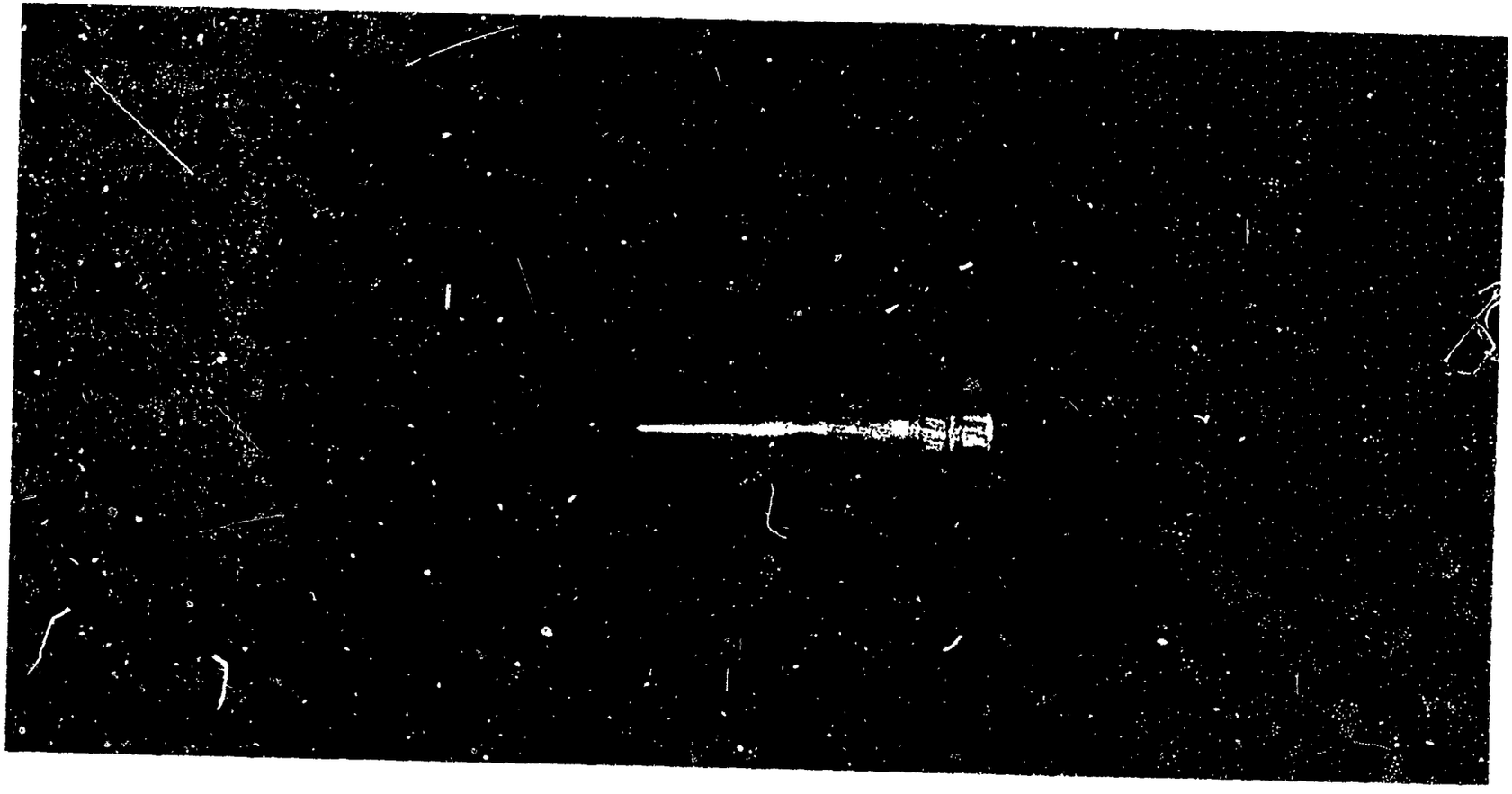
FIGURE 10. DOWNRANGE PHOTOGRAPHIC SETUP

Rounds 86, 87, and 88 are rounds fired through the N = 1.6 twist barrel. These bands are also in good condition. The gain twist sweep mentioned earlier is easily seen. The driving edge face is in very good condition for the entire width of the band.



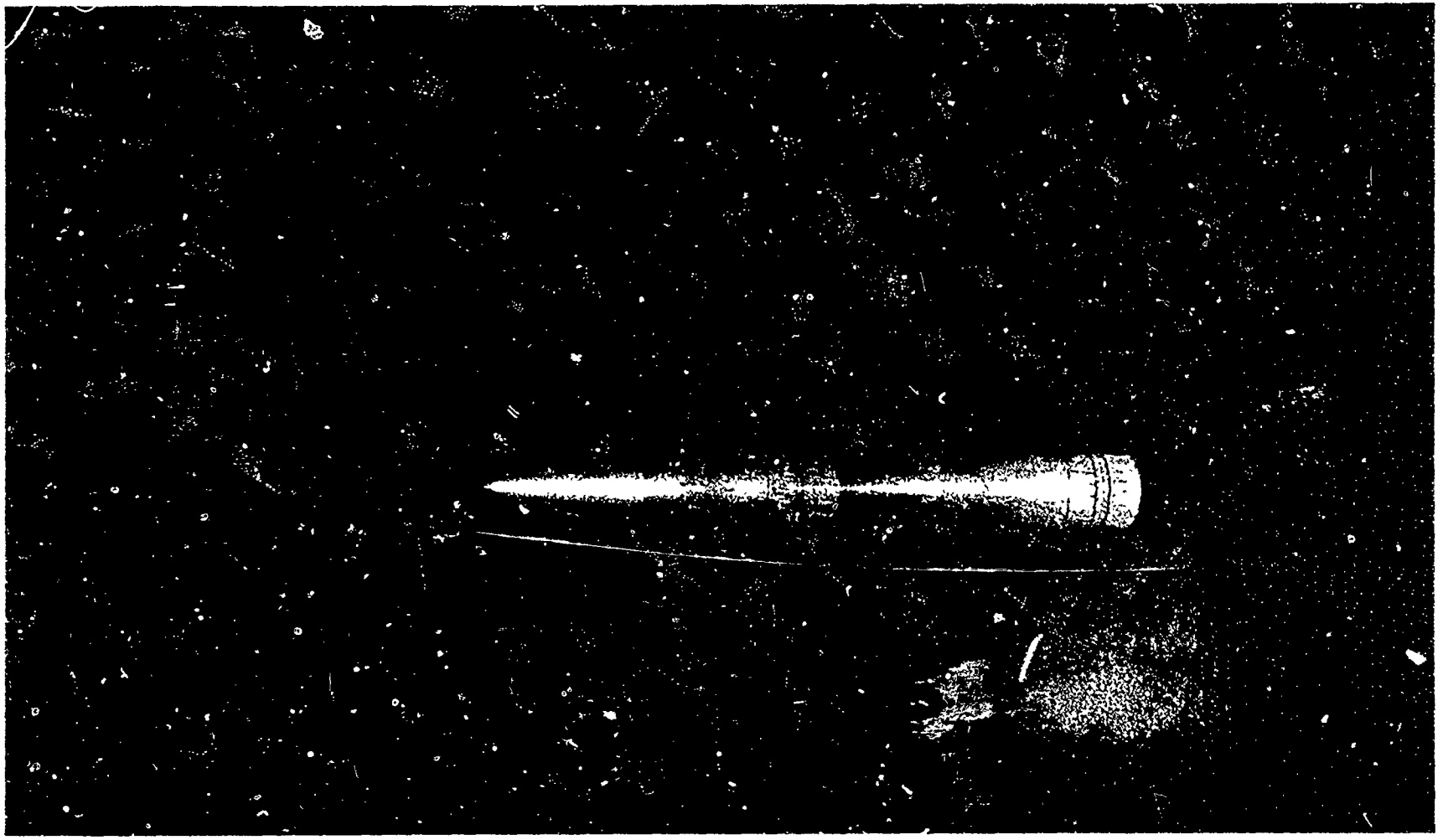
AMCAWS 30mm Mann Barrel
Rd. 63 - BBL 73D40042 - RIA Barrel

FIGURE 11.



AMCAWS 30mm Mann Barrel
Rd. 68 - BBL 73D40042 - RIA Barrel

FIGURE 12.

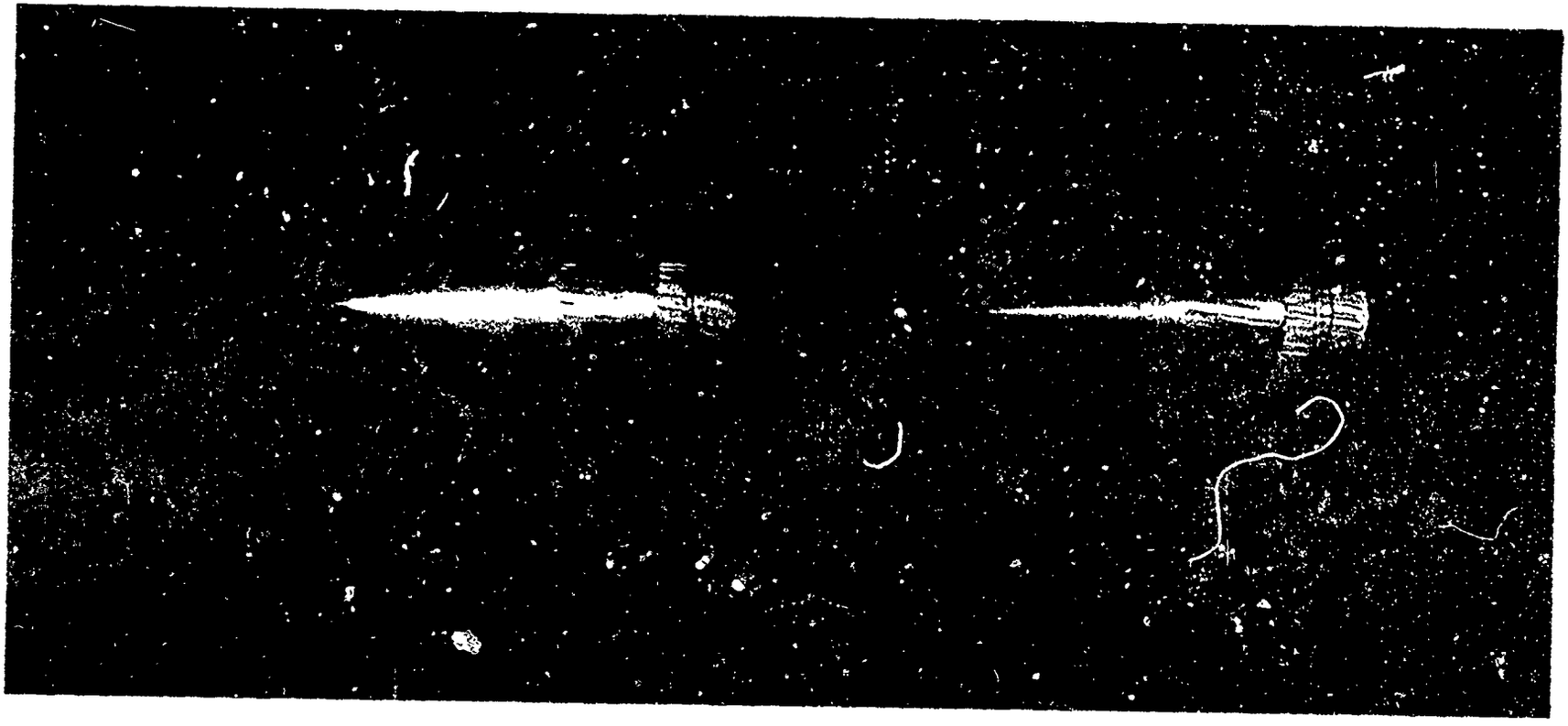


AMCAWS 30mm Mann Barrel
72 - BBL 73D40042 - RIA Barrel

FIGURE 13.

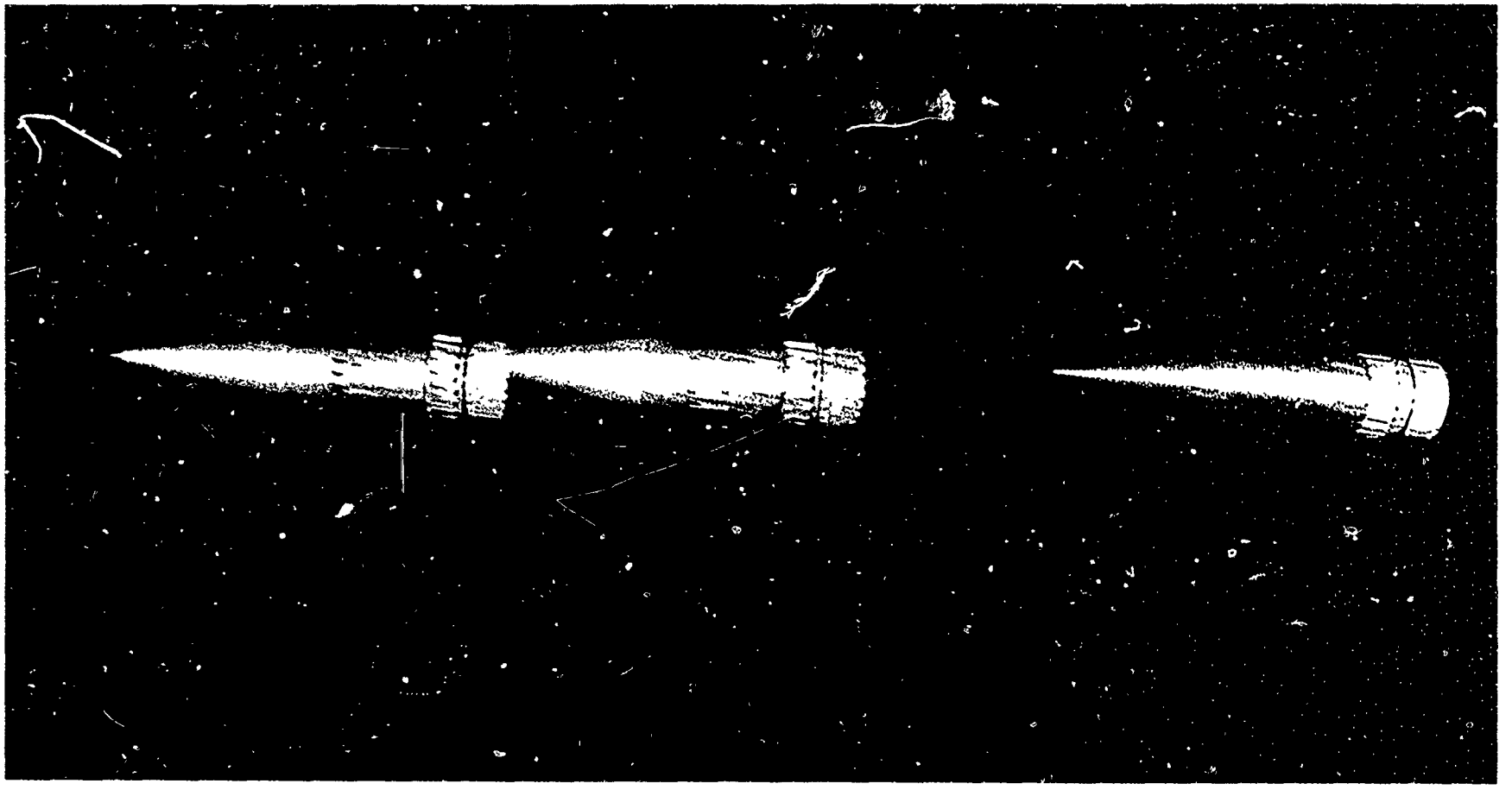
AMCAWS 30mm Mann Barrel
Rd. 74 - BBL 73D40046 - Constant Twist Barrel

FIGURE 14.



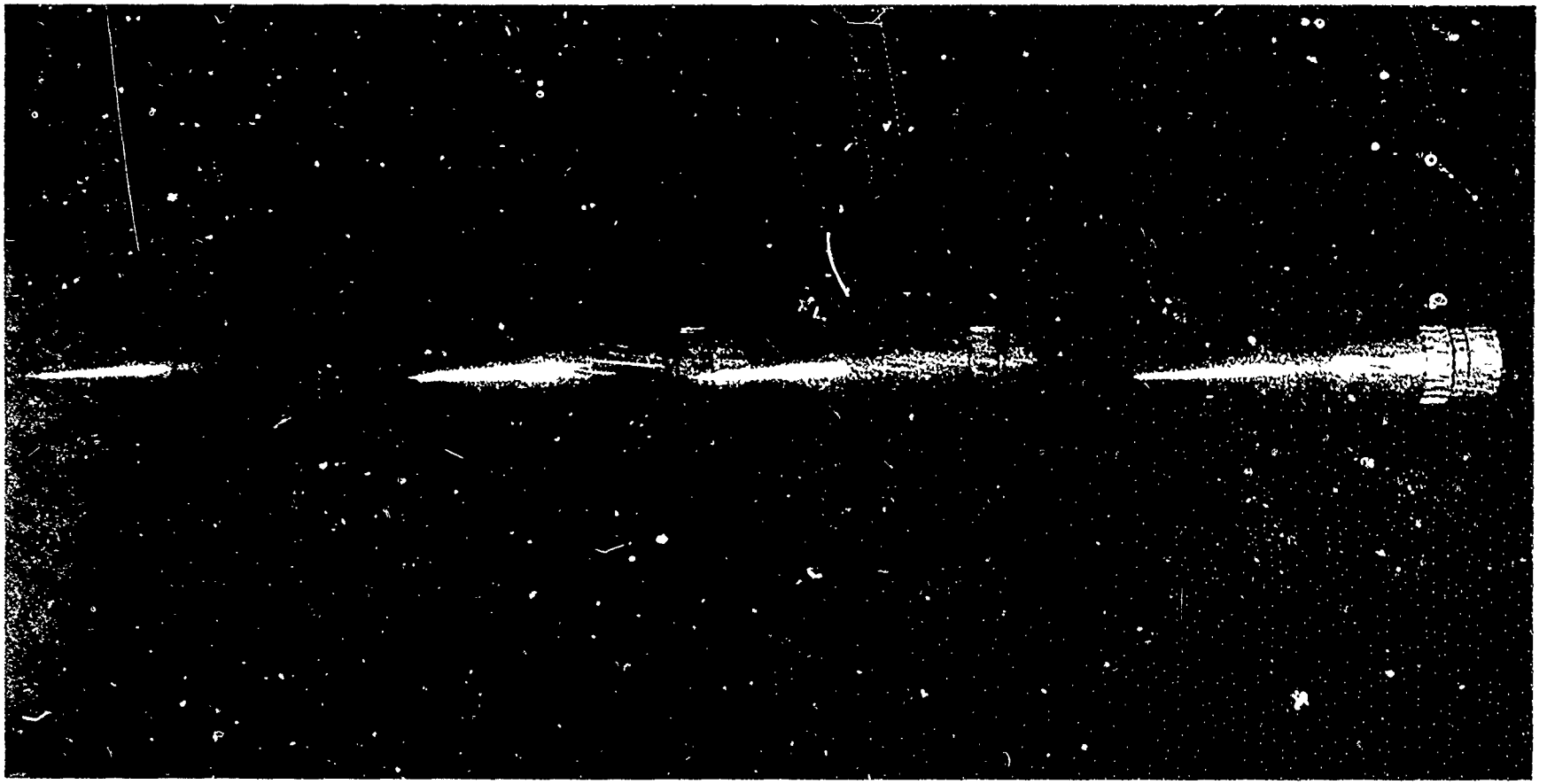
AMCAWS 30mm Mann Barrel
Rd. 75 - BBL 73D40046 - Constant Twist Barrel

FIGURE 15.



AMCAWS 30mm Mann Barrel
Rd. 80 - BBL 73D40046 - Constant Twist Barrel

FIGURE 16.

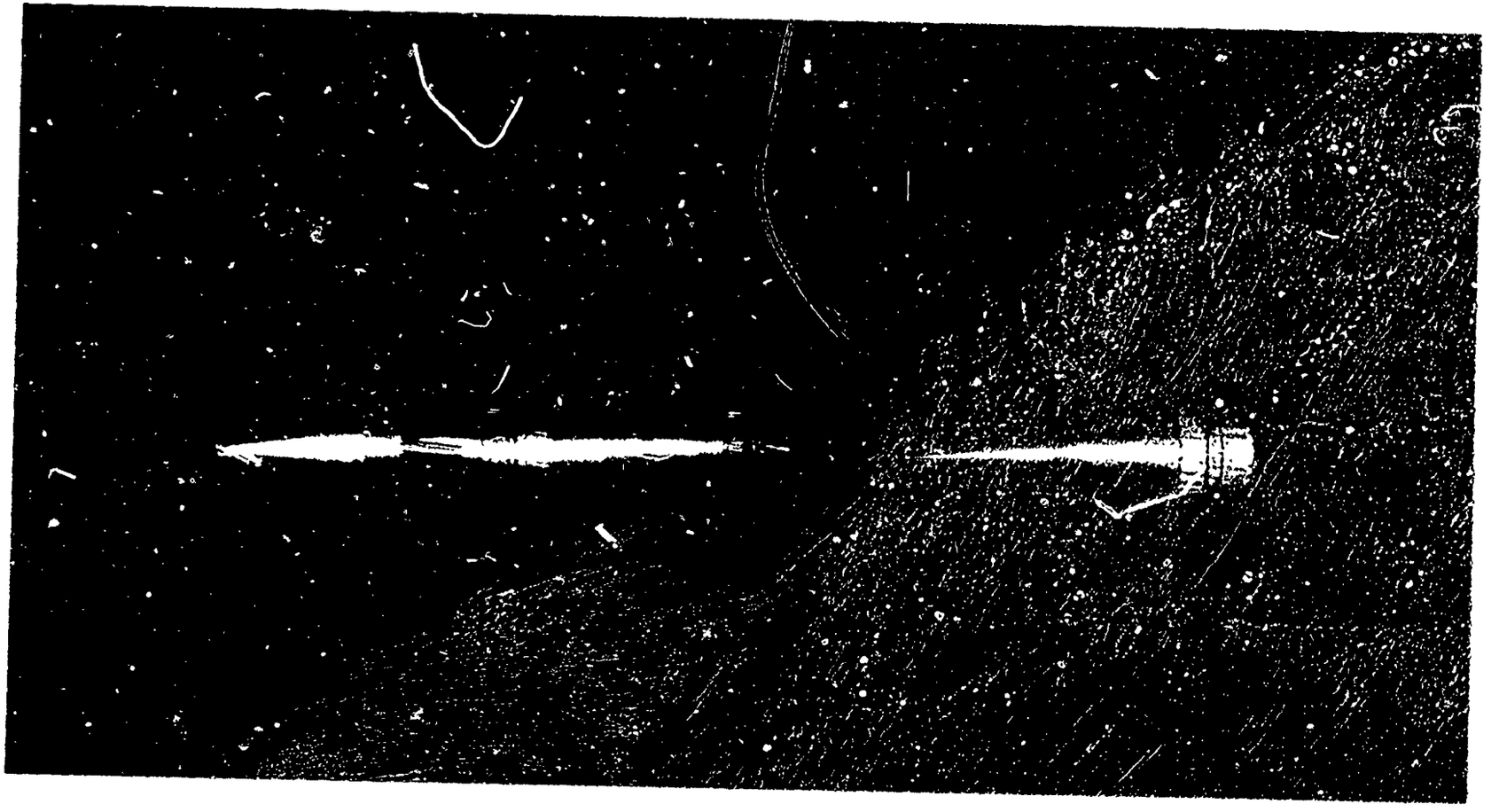


AMCAWS 30mm Mann Barrel
Rd. 86 - BBL 73D40079 - N=1.6 Barrel

FIGURE 17.

AMCAWS 30mm Mann Barrel
Rd. 87 - BBL 73D40079 - N=1.6 Barrel

FIGURE 18.



AMCAWS 30mm Mann Barrel
Rd. 88 - BBL 73D40079 - N=1.6 Barrel

FIGURE 19.

Test Series No.	Subtest No.	Barrel Twist	Peak Pressure	Action Time	V_{50}	In-Flight Picture	Comments
63	1	RIA	51.4	15.3	3562	Yes	
64	2	RIA	NA	14.4	3607	Yes	
65	3	RIA	26.2	8.3	2966	No	Split booster cup
66	4	RIA	29.2	NA	3082	No	Split booster cup
67	5	RIA	54.2	15.0	3622	No	
68	6	RIA	54.2	NA	3621	Yes	
69	7	RIA	54.8	16.9	3625	Yes	
70	8	RIA	50.1	10.6	3543	No	
71	9	RIA	52.2	12.4	3592	Yes	
72	10	RIA	54.4	12.9	3641	Yes	
73	11	RIA	58.8	14.0	3651	No	
74	12	CON	48.6	14.3	3520	Yes	
75	13	CON	50.0	15.0	3577	Yes	
76	14	CON	47.8	17.1	3563	No	
77	15	CON	53.2	12.1	3619	Yes	
78	16	CON	49.0	13.0	3536	Yes	
79	17	CON	NA	12.3	3516	Yes	
80	18	CON	51.0	13.2	3590	Yes	
81	19	CON	50.2	14.5	3586	Yes	
82	20	CON	49.8	13.6	3537	Yes	
83	21	1.6	45.8	19.3	3482	Yes	
84	22	1.6	44.4	NA	3460	No	
85	23	1.6	47.6	17.8	3508	Yes	
86	24	1.6	47.8	14.4	3475	Yes	
87	25	1.6	49.0	15.2	3506	Yes	
88	26	1.6	49.0	15.4	3557	Yes	
89	27	1.6	47.4	13.8	3487	Yes	
90	28	1.6	45.0	13.2	3468	Yes	

Table I. In-Flight Pictures for Rounds Fired Through RIA, Constant, N = 1.6 Barrels

EVALUATION OF RESULTS AND PREDICTIVE MODEL

The initial decision to fabricate the N = 1.6 barrel was made after the results of an early version of the Barrel/Torque Comparisons program were evaluated and the N = 1.6 barrel appeared to offer a significant reduction in peak torque and it was noted the torque curve approached the curve for the Hercules barrel (which was known not to strip bands).

The decision to fabricate a constant twist barrel was made because it was felt that so basic a barrel type should be evaluated with actual firings. Historical inertia and the high peak torque values led most everyone involved in this decision to feel this barrel would most certainly fail the band.

The firing tests and in-flight pictures indicate that future barrels fabricated for the AMCAWS 30 program, using current interior ballistics and copper rotating bands, should have constant twist or the N = 1.6 twist. The primary objective of this effort, choosing a replacement for the RIA twist barrel, has been met with that recommendation.

The secondary objective of this report, providing some coarse predictive model for evaluating the suitability of different band, interior ballistic, and twist combinations, is not as directly met. A model such as that will necessarily be simplistic since, as stated,

the "precise" mechanism of rotating band failure for this type of high performance ammunition has not been explicitly determined.

The model must also be simplistic because it is trying to generalize from a small amount of data and a limited firing test. The approach that will hopefully result in constructing the predictive model is one of essentially working from both ends to the middle (Figure 20). One end is the computer program that assumes no band failure and calculates the values listed in the data matrix. The other end is the result of the firing test. The middle is the model that will evaluate the computer program output and predict the same results as occured in the firing test.

The model presented here suggests that two things should be considered; (1) the peak stress values must be able to be sustained by the rotating band, and (2) the time over which the high values act is very important.

The first consideration seems somewhat obvious. The band properties must be able to resist the peak shear and bearing loads. Shear stresses for the barrels considered do not exceed 10,000 PSI so failure in shear does not appear to be a problem. The bearing stresses are much higher, approaching 40,000 PSI.

The difficulty in determining if the peak bearing stress values exceed the band properties is finding data on band properties. Pub-

PREDICTIVE MODEL APPROACH

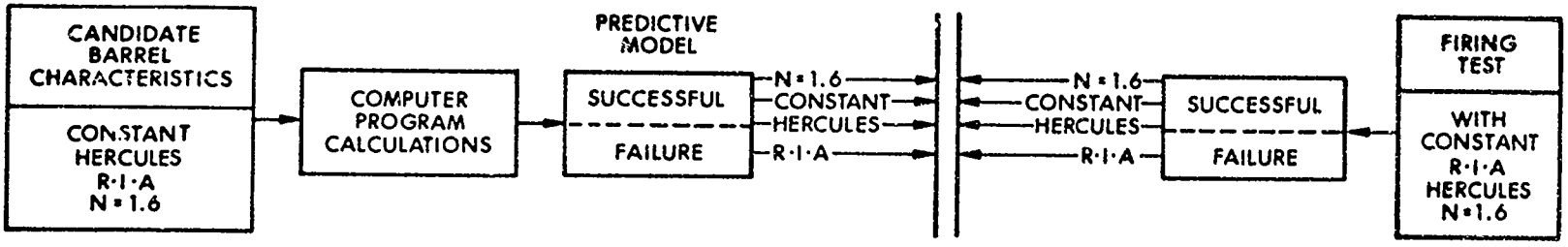


FIGURE 20

lished data from materials testing usually indicates that all rotating bands for high performance ammunition should fail. Most materials testing is done at a rate that does not begin to approach the rate of application of stresses in a gun. High strain rate tests do not usually result in data with easily comparable units, such as PSI. Rate of application certainly affects the ultimate limits of bearing strength and shear strength for the band material. One published value[1] suggests 20,000 PSI as an allowable copper rotating band bearing stress, but the three successful barrels exceed that value by 11% to 65%. None of the barrels considered are less than 20,000 PSI in bearing. The constant twist barrel has a peak bearing stress of 33,200 PSI, so that might be considered a minimum for a range of values that describe the ultimate limit for rotating band bearing stress. The indications that the band are stripped well down the RIA barrel tend to suggest that the band withstands even the 38,000 PSI peak bearing stress of the RIA twist barrel successfully.

The peak torque, bearing stress, and shear stress values are listed in Table 2. These are the peak values computed in the program. Actually, however, the peak values for the constant or the N = _._ barrels are not listed. The nonspinning rotating band moving at about 200-250 fps engraving onto the 9° or 3° twist theoretically (since a no shear condition is assumed) produces infinite peaks. These peaks

[1] J. Wolf and G. Cochran, Rotating Band/Rifling Interaction Study; General Electric Report 72APB552, November 1972.

Torques

Barrel	Band Position (in)	Time (msec)	Torque (in-lb)	
1.6	30.4	13.4	2378	108%
1.8	32.7	13.5	2316	105%
2.0	35.1	13.5	2274	103%
RIA	38.7	13.6	3101	141%
Hercules	30.4	13.5	2197	100%
Constant	6.7	12.5	3579	162%

Stresses

Barrel	Shearing Stress (psi)		Bearing Stress (psi)		
1.6	6613	105%	22210	111%	105%
1.8	6410	102%	21647	108%	102%
2.0	6288	100%	21250	106%	100%
RIA	9482	150%	38158	190%	179%
Hercules	6616	105%	27052	135%	127%
Constant	9037	143%	33190	165%	156%
		Suggested Values	20000	100%	

PEAK TORQUE AND STRESS VALUES

TABLE 2.

last for such a small time period that they can be neglected. The print-out shows torque for the constant twist barrel is 0.0 in-lbs when the band is .816 inches into the barrel and 57.1 in-lbs at a band position of 1.124 inches. The time increment is .1 milliseconds. These values infer the time duration for the very high torque values are probably on the order of microseconds. The Gun Tube Handbook[2] refers to a five microsecond duration for the decay of infinite torque to "acceptable" values for a 37mm gun with 1.0 inch free run and a $y = px^{1.625}$ rifling profile. This background is presented in an effort to demonstrate that the time duration of peak values is important (again, there is also a rate of application relationship).

Bearing stresses for the six barrels compared appear to be the most critical values coming out of the program. The range of these values is very high relative to all published data (directly comparable or not) for properties of this class of copper. Bearing stress also relates to the amount of displacement the driving edge experiences, which could significantly change the remaining shear area. This might possibly reduce it to a critical region. Band melting might be accelerated by higher bearing stresses and the higher frictional forces. These parameters, which can be associated with bearing stress, are also felt to be rate dependent.

---

[2]AMCPM 706-252, Engineering Design Handbook, Gun Series, Gun Tubes, February 1964.

The idea of time duration and rate dependence is the reason a comparison of the integral of bearing stresses with respect to time is offered as the second test in this two-step model. The program uses a trapazoid summation to integrate torque, bearing stresses, and shear stresses with respect to time and position. The values are listed in Table 3.

Once again, a number which represents the dividing line between success and failure, for the integral test, is not readily available. The dividing line value appears to be between 48 PSI-sec and 55 PSI-sec, assuming the RIA barrel does not cause band failure due to the first test.

The proposed predictive model utilizes: (1) a computer program to calculate stress values caused by proposed interior ballistic performance acting on the candidate rifling profiles, (2) rotating band materials properties that can be meaningfully compared to the calculated stress values, and (3) a comparison of the integrals of the bearing stress versus time curves for the candidate barrels. This predictive model, based on very limited data and without precise knowledge of the mechanism of band failure that actually occurs, is somewhat incomplete. The model will provide a basis for evaluating any significantly different interior ballistic performance, such as when AMCAWS 30 goes to a non-stop mode. While the model will be refined and corrected with more firings and additional research, it now provides a better basis for selecting a barrel twist than was available previously.

INTEGRAL VALUES

	TORQUE				SHEAR STRESS				BEARING STRESS			
	WRT TIME (IN-LB-SEC)		WRT POSITION (IN-LB-IN)		WRT TIME (PSI-SEC)		WRT POSITION (PSI-IN)		WRT TIME (PSI-SEC)		WRT POSITION (PSI-IN)	
N=1.6 Barrel	RANK		RANK		RANK		RANK		RANK		RANK	
	3	0.447 E+01 114%	3	0.147 E+06 141%	5	0.125 E+02 115%	3	0.421 E+06 160%	2	0.418 E+02 105%	2	0.137 E+07 142%
N=1.8 Barrel	4	0.447 E+01 114%	4	0.150 E+06 144%	4	0.125 E+02 115%	4	0.428 E+06 162%	3	0.418 E+02 105%	3	0.140 E+07 145%
N=2.0 Barrel	5	0.447 E+01 114%	5	0.152 E+06 145%	3	0.125 E+02 115%	5	0.432 E+06 164%	4	0.418 E+02 105%	4	0.142 E+07 146%
Hercules Barrel	1	0.392 E+01 100%	2	0.132 E+06 126%	2	0.119 E+02 109%	2	0.407 E+06 154%	5	0.483 E+02 121%	5	0.162 E+07 167%
Constant Twist Barrel	2	0.431 E+01 110%	1	0.104 E+06 100%	1	0.109 E+02 100%	1	0.264 E+06 100%	1	0.399 E+02 100%	1	0.969 E+06 100%
RIA Barrel	6	0.451 E+01 115%	6	0.167 E+06 160%	6	0.138 E+02 127%	6	0.520 E+06 197%	6	0.553 E+02 139%	6	0.205 E+07 212%

TABLE 3

CONCLUSIONS AND RECOMMENDATIONS

The Barrel/Torque Comparisons computer program can easily be changed to provide comparisons of many possible barrels with a set of nominal ballistics data or comparisons of one barrel with a range of ballistic performance. This is a useful design tool so that someone charged with releasing a barel drawing can do so with some assurance that the twist profile appears compatible with the interior ballistics of the round. An advanced gun and ammunition development program, such as AMCAWS 30, should check barrels about to be released against current interior ballistic performance.

The predictive model is admittedly simplistic, based, as it is, on limited data, limited experience, and limited intuition. The model is not, hopefully, one of the arbitrary interpretations discussed under Observations. Work, to whatever degree possible, should continue on refining such a predictive model as it will fill a very real need in designing one aspect of the gun-ammunition interface.

The success of the N = 1.6 barrel as indicated by the values coming out of the computer program and the firing tests, is due to its hybrid design. The initial rifling angle of 3° is a very important design element to reduce the total sweep experienced by the rotating band while the 1.6 exponential gain allows low band stresses throughout the barrel. The N = 1.6 barrel essentially takes the zero band sweep

aspect of a constant twist barrel and combines it reasonably successfully with the low peak values associated with gain twist barrels.

The goal of the initial effort of this work was to provide a replacement for the unsuccessful RIA twist barrel. The recommendation of the constant or the N = 1.6 twist barrels with the current AMCAWS 30 interior ballistic performance meets that goal. There is a very high degree of confidence in those recommendations since they were actually fired. Looking ahead in the AMCAWS 30 program to non-stop ballistics and plastic rotating bands, a secondary goal of evaluating barrel/band combinations without fabrication and firing developed. The predictive model presented is a first step in meeting that goal.

Specific conclusions and recommendations follow:

CONCLUSIONS:

1. Evaluate barrels about to be fabricated with current interior ballistics performance.

2. Current (May 1975) ballistic performance indicates N=1.6 or constant twist barrels should be used.

3. Rotating band sweep on gain twist barrels is a critical parameter that must be considered when suggesting a new gain twist function.

4. Rotating band sweep due to gain twist limits the rotating band width (width in the axial direction) that can be effectively used. Wider bands with gain twist barrels do not always have better survivability.

RECOMMENDATIONS:

1. Obtain better and more useable data on high rate properties of rotating band materials.

2. Refine the rotating band predictive model.

REFERENCES

1. J. Wolf and G. Cochran, Rotating Band/Rifling Interaction Study; General Electric Report 72APB552, November 1972.

2. AMCPM 706-252, Engineering Design Handbook, Gun Series, Gun Tubes, February 1964.

APPENDIX A

BARREL/TORQUE

COMPARISONS COMPUTER

PROGRAM WITH

CALCOMP GRAPHICS OUTPUT

```
C*****00000010
C*****00000020
C*****00000030
C*****00000040
C*****00000050
C                          BARREL/TORQUE COMPARISONS                    00000060
C                    PROGRAM BY MICHAEL R. KANE  (SARRI-LW-A)           00000070
C*****00000080
C*****00000090
C*****00000100
C*****00000110
C*****00000120
C*****00000130
C*****00000140
C          TORQUE ON AMCAWS 30MM TP PROJECTILE ALONG BARREL LENGTH      00000150
C           BASED ON   AMCAWS 30 INTERIOR BALLISTICS PROGRAM DATA       00000160
C*****00000170
C*****00000180
C*****00000190
C    NUMBER OF DATA CARDS IS LIMITED BY THE SIZE OF THE IBDATA ARRAY    00000200
C*****00000210
C*****00000220
C*****00000230
C  DATA MATRIX IS AS FOLLOWS.....                                       00000240
C         IBDATA(J,1)=TIME  (SECONDS)                                   00000250
C         IBDATA(J,2)= POSITION  (INCHES)                               00000260
C         IBDATA(J,3)= VELOCITY  (FT/SEC)                               00000270
C         IBDATA(J,4)= ACCELERATION  (FT/SEC/SEC)                       00000280
C         IBDATA(J,5)= CHAMBER PRESSURE  (PSI)                          00000290
C         BBL_( J,1)=ROTATION  (RADIANS)                                00000300
C         BBL_( J,2)=ROTATIONAL VELOCITY  (RAD/SEC)                     00000310
C         BBL_( J,3)=ROTATIONAL ACCELERATION  (RAD/SEC/SEC)             00000320
C         BBL_( J,4)=TORQUE  (IN-LBS)                                   00000330
C         BBL_( J,5)=TOTAL SHEAR AREA REMAINING ON BAND (IN**2)         00000340
C         BBL_( J,6)=Y VALUE OF LAND  (INCHES)                          00000350
C         BBL_( J,7)= FIRST DERIVITIVE OF RIFLING EQUATION              00000360
C         BBL_( J,8)=SECOND DERIVITIVE OF RIFLING EQUATION              00000370
C         BBL_( J,9)=SHEAR STRESS ON BAND  (PSI)                        00000380
C         BBL_(J,10)=BEARING STRESS ON BAND FACES  (PSI)                00000390
C*****00000400
C*****00000410
C*****00000420
C         SIGNIFICANT FIGURES IN EXCESS OF THE MACHINE ACCURANCY        00000430
C                    ARE INCLUDED FOR REFERENCE                         00000440
C*****00000450
C*****00000460
C*****00000470
0001          REAL IBDATA(250,5),BBL1(250,10),BBL2(250,10),BBL3(250,10),IPOLAR, 00000480
             1N1,N2,N3,MPROJ,XDUMMY(252),YDUMMY(252),                   00000490
             2BBLMER(250,10),BBLAMC(250,10),BBLCON(250,10)              00000500
0002          DIMENSION IBUF(1000)                                      00000510
0003          J=0                                                       00000520
0004       20 READ(5,30,END=40) A,B,C,D,E                               00000530
```

```
0005          30 FORMAT(5(E16.7))                                                00000540
0006             J=J+1                                                           00000550
0007             IBDATA(J,1)=A                                                   00000560
0008             IBDATA(J,2)=B                                                   00000570
0009             IBDATA(J,3)=C                                                   00000580
0010             IBDATA(J,4)=D                                                   00000590
0011             IBDATA(J,5)=E                                                   00000600
0012             GO TO 20                                                        00000610
0013          40 CONTINUE                                                        00000620
0014             NSET=J                                                          00000630
0015             NVAL=NSET*2                                                     00000640
0016             RAD2DG=57.2958279                                               00000650
0017             SLOPE=.157788                                                   00000660
0018             ABORE=1.10008                                                   00000670
0019             R=.59175                                                        00000680
0020             STAR=1.0E70                                                     00000690
0021             RHO=.5856608                                                    00000700
0022             IPOLAR=3.8043E-04                                               00000710
0023             MPROJ=1.10913E-03                                               00000720
0024             DO 45 J=1,NSET                                                  00000730
0025             IBDATA(J,3)=IBDATA(J,3)*12.0                                    00000740
0026             IBDATA(J,4)=IBDATA(J,4)*12.0                                    00000750
0027          45 CONTINUE                                                        00000760
              C                                                                  00000770
              C                                                                  00000780
              C***** BARRELS N=1.6,N=1.8,N=2.0 CALCULATIONS                      00000790
0028             START=1.0                                                       00000800
0029             END=81.0                                                        00000810
0030             P1=6.410420509E-03                                              00000820
0031             P2=2.086332E-03                                                 00000830
0032             P3=6.5862728ZE-04                                               00000840
0033             N1=1.6                                                          00000850
0034             N2=1.8                                                          00000860
0035             N3=2.0                                                          00000870
0036             XP1=14.15822977                                                 00000880
0037             XP2=25.97271115                                                 00000890
0038             XP3=38.7855972                                                  00000900
0039             AMT1=9.384274135                                                00000910
0040             AMT2=9.37723553                                                 00000920
0041             AMT3=9.446034489                                                00000930
0042             DO 70 J=1,NSET                                                  00000940
0043             IF(IBDATA(J,2).GE.START) GO TO 50                               00000950
0044             DO 46 M=1,10                                                    00000960
0045             BBL1(J,M)=0.0                                                   00000970
0046             BBL2(J,M)=0.0                                                   00000980
0047             BBL3(J,M)=0.0                                                   00000990
0048          46 CONTINUE                                                        00001000
0049             BBL1(J,5)=STAR                                                  00001010
0050             BBL2(J,5)=STAR                                                  00001020
0051             BBL3(J,5)=STAR                                                  00001030
0052             GO TO 70                                                        00001040
0053          50 IF(IBDATA(J,2).GT.END) GO TO 60                                 00001050
0054             CALL GAINP(J,P1,N1,XP1,T,T1,T2,TORQUE,ALEFT1,Y,DYDX,D2YDX2,     00001060
```

```
     2SHEAR,BEAR,IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),IBDATA(J,5),          00001070
     1START,R,IPOLAR,MPROJ,RHO,ABORE)                                      00001080
0055  BBL1( J,1)=T                                                         00001090
0056  BBL1( J,2)=T1                                                        00001100
0057  BBL1( J,3)=T2                                                        00001110
0058  BBL1( J,4)=TORQUE                                                    00001120
0059  BBL1( J,5)=ALEFT1                                                    00001130
0060  BBL1( J,6)=Y                                                         00001140
0061  BBL1( J,7)=ATAN(DYDX)*RAD2DG                                         00001150
0062  BBL1( J,8)=D2YDX2                                                    00001160
0063  BBL1( J,9)=SHEAR                                                     00001170
0064  BBL1(J,10)=BEAR                                                      00001180
0065  CALL GAINP(J,P2,N2,XP2,T,T1,T2,TORQUE,ALEFT2,Y,DYDX,D2YDX2,          00001190
     2SHEAR,BEAR,IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),IBDATA(J,5),          00001200
     1START,R,IPOLAR,MPROJ,RHO,ABORE)                                      00001210
0066  BBL2( J,1)=T                                                         00001220
0067  BBL2( J,2)=T1                                                        00001230
0068  BBL2( J,3)=T2                                                        00001240
0069  BBL2( J,4)=TORQUE                                                    00001250
0070  BBL2( J,5)=ALEFT2                                                    00001260
0071  BBL2( J,6)=Y                                                         00001270
0072  BBL2( J,7)=ATAN(DYDX)*RAD2DG                                         00001280
0073  BBL2( J,8)=D2YDX2                                                    00001290
0074  BBL2( J,9)=SHEAR                                                     00001300
0075  BBL2(J,10)=BEAR                                                      00001310
0076  CALL GAINP(J,P3,N3,XP3,T,T1,T2,TORQUE,ALEFT3,Y,DYDX,D2YDX2,          00001320
     2SHEAR,BEAR,IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),IBDATA(J,5),          00001330
     1START,R,IPOLAR,MPROJ,RHO,ABORE)                                      00001340
0077  BBL3( J,1)=T                                                         00001350
0078  BBL3( J,2)=T1                                                        00001360
0079  BBL3( J,3)=T2                                                        00001370
0080  BBL3( J,4)=TORQUE                                                    00001380
0081  BBL3( J,5)=ALEFT3                                                    00001390
0082  BBL3( J,6)=Y                                                         00001400
0083  BBL3( J,7)=ATAN(DYDX)*RAD2DG                                         00001410
0084  BBL3( J,8)=D2YDX2                                                    00001420
0085  BBL3( J,9)=SHEAR                                                     00001430
0086  BBL3(J,10)=BEAR                                                      00001440
0087  GO TO 70                                                             00001450
0088 60 BBL1( J,6)=SLOPE*(IBDATA(J,2)-END)+AMT1                            00001460
0089    BBL2( J,6)=SLOPE*(IBDATA(J,2)-END)+AMT2                            00001470
0090    BBL3( J,6)=SLOPE*(IBDATA(J,2)-END)+AMT3                            00001480
0091    BBL1( J,1)=BBL1(J,6)/R                                             00001490
0092    BBL2( J,1)=BBL2(J,6)/R                                             00001500
0093    BBL3( J,1)=BBL3(J,6)/R                                             00001510
0094    BBL1( J,2)=SLOPE*IBDATA(J,3)/R                                     00001520
0095    BBL2( J,2)=BBL1(J,2)                                               00001530
0096    BBL3( J,2)=BBL1(J,2)                                               00001540
0097    BBL1( J,3)=SLOPE*IBDATA(J,4)/R                                     00001550
0098    BBL2( J,3)=BBL1(4,3)                                               00001560
0099    BBL3( J,3)=BBL1(4,3)                                               00001570
0100    BBL1( J,4)=IPOLAR*BBL1(J,3)                                        00001580
0101    BBL2( J,4)=BBL1(J,4)                                               00001590
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0102              BBL3( J,4)=BBL1(J,4)                                          00001600
0103              BBL1( J,5)=ALEFT1                                             00001610
0104              BBL2( J,5)=ALEFT2                                             00001620
0105              BBL3( J,5)=ALEFT3                                             00001630
0106              BBL1( J,7)=ATAN(SLOPE)*RAD2DG                                 00001640
0107              BBL2( J,7)=BBL1(J,7)                                          00001650
0108              BBL3( J,7)=BBL1(J,7)                                          00001660
0109              BBL1( J,8)=0.0                                                00001670
0110              BBL2( J,8)=0.0                                                00001680
0111              BBL3( J,8)=0.0                                                00001690
0112              BBL1( J,9)=BBL1( J,4)*2.496                                   00001700
0113              BBL2( J,9)=BBL2( J,4)*2.496                                   00001710
0114              BBL3( J,9)=BBL3( J,4)*2.496                                   00001720
0115              BBL1(J,10)=BBL1( J,4)*9.388                                   00001730
0116              BBL2(J,10)=BBL2( J,4)*9.388                                   00001740
0117              BBL3(J,10)=BBL3( J,4)*9.388                                   00001750
0118           70 CONTINUE                                                      00001760
               C                                                               00001770
               C                                                               00001780
               C***** BARREL RIA CALCULATIONS                                  00001790
0119              START=4.0                                                     00001800
0120              END=73.25                                                     00001810
0121              AMT=5.9565                                                    00001820
0122              DO 300 J=1,NSET                                               00001830
0123              IF(IBDATA(J,2).GT.START) GO TO 320                            00001840
0124              DO 310 M=1,10                                                 00001850
0125           310 BBLAMC(J,M)=0.0                                              00001860
0126              BBLAMC(J,5)=.66877E                                           00001870
0127              IF(IBDATA(J,2).LE.1.0) BBLAMC(J,5)=STAR                       00001880
0128              GO TO 300                                                     00001890
0129           320 IF(IBDATA(J,2).GE.END) GO TO 330                             00001900
0130              CALL AAMC30(IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),START,K,RHO,  00001910
                 1ABORE,IBDATA(J,5),IPOLAR,MPROJ,Y,T,T1,T2,DYDX,D2YDX2,TORQUE,  00001920
                 2ALEFT,SHEAR,BEAR)                                            00001930
0131              BBLAMC( J,1)=T                                                00001940
0132              BBLAMC( J,2)=T1                                               00001950
0133              BBLAMC( J,3)=T2                                               00001960
0134              BBLAMC( J,4)=TORQUE                                           00001970
0135              BBLAMC( J,5)=ALEFT                                            00001980
0136              BBLAMC( J,6)=Y                                                00001990
0137              BBLAMC( J,7)=ATAN(DYDX)*RAD2DG                                00002000
0138              BBLAMC( J,8)=D2YDX2                                           00002010
0139              BBLAMC( J,9)=SHEAR                                            00002020
0140              BBLAMC(J,10)=BEAR                                             00002030
0141              GO TO 300                                                     00002040
0142           330 CALL CONST(SLOPE,END,IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),AMT,00002050
                 1K,RHO,ABORE,IBDATA(J,5),Y,T,T1,T2,TORQUE,ALEFT9,DYDX,D2YDX2,  00002060
                 2SHEAR,BEAR)                                                  00002070
0143              BBLAMC( J,1)=T                                                00002080
0144              BBLAMC( J,2)=T1                                               00002090
0145              BBLAMC( J,3)=T2                                               00002100
0146              BBLAMC( J,4)=TORQUE                                           00002110
0147              BBLAMC( J,5)=ALEFT                                            00002120
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0148              BBLAMC( J,6)=Y                                                00002130
0149              BBLAMC( J,7)=ATAN(DYDX)*RAD2DG                                00002140
0150              BBLAMC( J,8)=D2YDX2                                           00002150
0151              BBLAMC( J,9)=SHEAR                                            00002160
0152              BBLAMC(J,10)=BEAR                                             00002170
0153            300 CONTINUE                                                    00002180
                C                                                               00002190
                C                                                               00002200
                C***** BARREL HERCULES CALCULATIONS                            00002210
0154              START=1.0                                                     00002220
0155              P3=.01008                                                     00002230
0156              N3=1.5                                                        00002240
0157              XP3=0.0                                                       00002250
0158              DO 100 J=1,NSET                                               00002260
0159              IF(IBDATA(J,2).GT.1.0) GO TO 90                               00002270
0160              DO 80 M=1,10                                                  00002280
0161             80 BBLHER(J,M)=0.0                                             00002290
0162              BBLHER(J,5)=STAR                                              00002300
0163              GO TO 100                                                     00002310
0164             90 CONTINUE                                                    00002320
0165              CALL GAINP(J,P3,N3,XP3,T,T1,T2,TORQUE,ALEFT,Y,DYDX,D2YDX2,    00002330
                 1SHEAR,BEAR,IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),IBDATA(J,5),   00002340
                 1START,R,IPOLAR,MPROJ,RHO,ABORE)                               00002350
                C       **** SHEAR AREA CALCULATION. AREA IS AREA SWEPT, ALEFT IS AREA 00002360
                C       **** REMAINING ON THE ROTATING BAND PER SEGMENT        00002370
                C       **** DRIVE IS DRIVING EDGE AREA                        00002380
                C       **** SUMFOR IS SUMMATION OF FORCES AT RADIUS TO PRODUCE TORQUE 00002390
0166              AREA=.0648000*DYDX                                            00002400
0167              ALEFT=(0.0334627-AREA)*20.0                                   00002410
0168              SUMFOR=TORQUE/R                                               00002420
0169              SHEAR=SUMFOR/ALEFT                                            00002430
0170              DRIVE=(.3600/COS(ATAN(DYDX)))*20.0*0.019                      00002440
0171              BEAR=SUMFOR/DRIVE                                             00002450
0172              BBLHER( J,1)=T                                                00002460
0173              BBLHER( J,2)=T1                                               00002470
0174              BBLHER( J,3)=T2                                               00002480
0175              BBLHER( J,4)=TORQUE                                           00002490
0176              BBLHER( J,5)=ALEFT                                            00002500
0177              BBLHER( J,6)=Y                                                00002510
0178              BBLHER( J,7)=ATAN(DYDX)*RAD2DG                                00002520
0179              BBLHER( J,8)=D2YDX2                                           00002530
0180              BBLHER( J,9)=SHEAR                                            00002540
0181              BBLHER(J,10)=BEAR                                             00002550
0182            100 CONTINUE                                                    00002560
                C                                                               00002570
                C                                                               00002580
                C***** BARREL CONSTANT CALCULATIONS                            00002590
0183              END=1.0                                                       00002600
0184              AMT=0.0                                                       00002610
0185              DO 201 J=1,NSET                                               00002620
0186              IF(IBDATA(J,2).GE.1.0) GO TO 202                              00002630
0187              DO 203 M=1,10                                                 00002640
0188            203 BBLCON(J,M)=0.0                                             00002650
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0189              BBLCON(J,5)=STAR                                                00002660
0190              GO TO 201                                                       00002670
0191            202 CALL CONST(SLOPE,END,IBDATA(J,2),IBDATA(J,3),IBDATA(J,4),AMT,  00002680
                   1K,RHO,ABORE,IBDATA(J,5),Y,T,T1,T2,TORQUE,ALEFT,DYDX,D2YDX2,    00002690
                   2SHEAR,BEAR)                                                    00002700
0192              BBLCON( J,1)=T                                                  00002710
0193              BBLCON( J,2)=T1                                                 00002720
0194              BBLCON( J,3)=T2                                                 00002730
0195              BBLCON( J,4)=TORQUE                                             00002740
0196              BBLCON( J,5)=ALEFT                                              00002750
0197              BBLCON( J,6)=Y                                                  00002760
0198              BBLCON( J,7)=ATAN(DYDX)*RAD2DG                                  00002770
0199              BBLCON( J,8)=D2YDX2                                             00002780
0200              BBLCON( J,9)=SHEAR                                              00002790
0201              BBLCON(J,10)=BEAR                                               00002800
0202            201 CONTINUE                                                      00002810
                C***** END OF BARREL CALCULATIONS                                 00002820
                C                                                                 00002830
                C                                                                 00002840
                C*****************************************************************00002850
                C                                                                 00002860
                C                                                                 00002870
0203              DO 75 J=1,NSET                                                  00002880
0204              IBDATA(J,3)=IBDATA(J,3)/12.0                                    00002890
0205              IBDATA(J,4)=IBDATA(J,4)/12.0                                    00002900
0206            75 CONTINUE                                                       00002910
0207              CALL PLOTS(IBUF,1000,14)                                        00002920
0208              CALL FACTOR(1.0)                                                00002930
0209              CALL NEWPEN(1)                                                  00002940
0210              CALL PLOT(0.0,-36.0,-3)                                         00002950
0211              CALL PLOT(0.0,2.5,-3)                                           00002960
0212               CALL FACTOR(0.9)                                               00002970
                C*********      SET UP FIRST VALUES AND DELTA VALUES  FOR PLOTS  ********00002980
0213              XP=10.0                                                         00002990
0214              XT=10.0                                                         00003000
0215              YT=8.0                                                          00003010
0216              N18=NSET+1                                                      00003020
0217              N19=NSET+2                                                      00003030
0218              CALL PLOT(10.0,0.0,-3)                                          00003040
0219              CALL SCALE(IBDATA(1,2),YT,NSET,1)                               00003050
0220              CALL SCALE(IBDATA(1,3),YT,NSET,1)                               00003060
0221              CALL SCALE(IBDATA(1,4),YT,NSET,1)                               00003070
0222              CALL SCALE(IBDATA(1,5),YT,NSET,1)                               00003080
0223              CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),  00003090
                  *          +40,YT,90.0,IBDATA(N18,2),IBDATA(N19,2))             00003100
0224              CALL AXIS(-0.5,0.0,25HPROJECTILE VELOCITY (FPS),                00003110
                  @          +25,YT,90.0,IBDATA(N18,3),IBDATA(N19,3))             00003120
0225              CALL AXIS(-1.0,0.0,38HPROJECTILE ACCELERATION (FEET/SEC/SEC),   00003130
                  @          +38,YT,90.0,IBDATA(N18,4),IBDATA(N19,4))             00003140
0226              CALL AXIS(-1.5,0.0,22HCHAMBER PRESSURE (PSI),                   00003150
                  @          +22,YT,90.0,IBDATA(N18,5),IBDATA(N19,5))             00003160
0227              XDUMMY(1)=0.0                                                   00003170
0228              XDUMMY(2)=0.015                                                 00003180
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0229              CALL SCALE(XDUMMY,XI,2,1)                                    00003190
0230              IFV=XDUMMY(3)                                                00003200
0231              IDV=XDUMMY(4)                                                00003210
0232              IBDATA(N18,1)=IFV                                            00003220
0233              IBDATA(N19,1)=IDV                                            00003230
0234              CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),      00003240
                 *          -33,XT,0.0,IFV,IDV)                              00003250
0235              CALL LINE(IBDATA(1,1),IBDATA(1,2),NSET,1,7,5)                00003260
0236              CALL LINE(IBDATA(1,1),IBDATA(1,3),NSET,1,7,0)                00003270
0237              CALL LINE(IBDATA(1,1),IBDATA(1,4),NSET,1,7,11)               00003280
0238              CALL LINE(IBDATA(1,1),IBDATA(1,5),NSET,1,7,12)               00003290
0239              CALL LEGND1(8.10,4.00,1)                                     00003300
0240              CALL PLOT(20.0,0.0,-3)                                       00003310
0241              XDUMMY(1)=-10.0                                              00003320
0242              XDUMMY(2)=90.0                                               00003330
0243               CALL SCALE(XDUMMY,XP,2,1)                                   00003340
0244              PFV=XDUMMY(3)                                                00003350
0245              PDV=XDUMMY(4)                                                00003360
0246              IBDATA(N18,2)=PFV                                            00003370
0247              IBDATA(N19,2)=PDV                                            00003380
0248              CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES), 00003390
                 *          -40,XP,0.0,PFV,PDV)                              00003400
0249              CALL AXIS( 0.0,0.0,25HPROJECTILE VELOCITY (FPS),             00003410
                 *          +25,YT,90.0,IBDATA(N18,3),IBDATA(N19,3))         00003420
0250              CALL AXIS(-0.5,0.0,38HPROJECTILE ACCELERATION (FEET/SEC/SEC), 00003430
                 *          +38,YT,90.0,IBDATA(N18,4),IBDATA(N19,4))         00003440
0251              CALL AXIS(-1.0,0.0,22HCHAMBER PRESSURE (PSI),                00003450
                 *          +22,YT,90.0,IBDATA(N18,5),IBDATA(N19,5))         00003460
0252              CALL LINE(IBDATA(1,2),IBDATA(1,3),NSET,1,7,0)                00003470
0253              CALL LINE(IBDATA(1,2),IBDATA(1,4),NSET,1,7,11)               00003480
0254              CALL LINE(IBDATA(1,2),IBDATA(1,5),NSET,1,7,12)               00003490
0255              CALL LEGND1(7.80,4.60,2)                                     00003500
0256              CALL PLOT(20.0,0.0,-3)                                       00003510
0257               CALL SCALE(BBLCON(1,4),YT,NSET,1)                           00003520
0258              QFV=BBLCON(N18, 4)                                           00003530
0259              QDV=BBLCON(N19,4)                                            00003540
0260              BBL1(N18,4)=QFV                                              00003550
0261              BBL1(N19,4)=QDV                                              00003560
0262              BBL2(N18,4)=QFV                                              00003570
0263              BBL2(N19,4)=QDV                                              00003580
0264              BBL3(N18,4)=QFV                                              00003590
0265              BBL3(N19,4)=QDV                                              00003600
0266              BBLHER(N18,4)=QFV                                            00003610
0267              BBLHER(N19,4)=QDV                                            00003620
0268              BBLAMC(N18,4)=QFV                                            00003630
0269              BBLAMC(N19,4)=QDV                                            00003640
0270              BBLCON(N18,4)=QFV                                            00003650
0271              BBLCON(N19,4)=QDV                                            00003660
0272              XDUMMY(1)=0.0-1000.                                          00003670
0273              XDUMMY(2)=10000.                                             00003680
0274              CALL SCALE(XDUMMY,YT,2,1)                                    00003690
0275              SHRFV=XDUMMY(3)                                              00003700
0276              SHRDV=XDUMMY(4)                                              00003710
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      XDUMMY(1)=0.0-4000.
      XDUMMY(2)=40000.
      CALL SCALE(XDUMMY,YT,2,1)
      BEARFV=XDUMMY(3)
      BEARDV=XDUMMY(4)
      BBL1(N18,9)=SHRFV
      BBL2(N18,9)=SHRFV
      BBL3(N18,9)=SHRFV
      BBL AMC(N18,9)=SHRFV
      BBLHER(N18,9)=SHRFV
      BBLCON(N18,9)=SHRFV
      BBL1(N19,9)=SHRDV
      BBL2(N19,9)=SHRDV
      BBL3(N19,9)=SHRDV
      BBLAMC(N19,9)=SHRDV
      BBLHER(N19,9)=SHRDV
      BBLCON(N19,9)=SHRDV
      BBLCON(N18,10)=BEARFV
      BBLHER(N18,10)=BEARFV
      BBLAMC(N18,10)=BEARFV
      BBL3(N18,10)=BEARFV
      BBL2(N18,10)=BEARFV
      BBL1(N18,10)=BEARFV
      BBL1(N19,10)=BEARDV
      BBL2(N19,10)=BEARDV
      BBL3(N19,10)=BEARDV
      BBLAMC(N19,10)=BEARDV
      BBLHER(N19,10)=BEARDV
      BBLCON(N19,10)=BEARDV
      SET=1.0
C*****          OUTPUT FOR N=1.6 BARREL      *************
      WRITE(6,1)
    1 FORMAT('1','      ' ////////////////////// '0', 20X,
     @          'BARREL 1, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.00645
     1906*X**1.6,      N=1.6 BARREL')
      WRITE(6,400)
  400 FORMAT('1','BARREL 1, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.00645
     1906*X**1.6,      N=1.6 BARREL')
          WRITE(6,210)
      DO 270 J=1,NSET
      WRITE(6,200)J,IBDATA(J,2),BBL1(J,6),BBL1(J,4),BBL1(J,5),
     0BBL1(J,9),BBL1(J,10),IBDATA(J,1),BBL1(J,7),J
  270 CONTINUE
      WRITE(6,7)
      CALL FPLOT(NSET,1,IBDATA(1,2),  BBL1(1,4),0,SET,SET,SET,SET)
      WRITE(6,8)
      CALL FPLOT(NSET,1,IBDATA(1,1),  BBL1(1,4),0,SET,SET,SET,SET)
       CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),
     @          +35,YT,90,0,QFV,QDV)
      CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),
     @          -40,XP,0.0,PFV,PDV)
       CALL LINE(IBDATA(1,2),BBL1(1,4),NSET,1,15,11)
      CALL SYMBOL(4.2,7.5,.21,12HN=1.6 BARREL,0.0,+12)
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0323          CALL LINE(IBDATA(1,2),BBL1(1,9),NSET,1,25,1)
0324          CALL LINE(IBDATA(1,2),BBL1(1,10),NSET,1,20,2)
0325          CALL AXIS(-1.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),
             1+35,YT,90.0,SHRFV,SHRDV)
0326          CALL AXIS(-.5,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),
             1+37,YT,90.0,BEARFV,BEARDV)
0327          CALL LEGEND(6.000,1.222)
0328          CALL PLOT(15.0,0.0,-3)
0329           CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),
             *          +35,YT,90.0,QFV,QDV)
0330          CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),
             *          -33,XT,0.0,TFV,TDV)
0331           CALL LINE( IBDATA(1,1),BBL1(1,4),NSET,1,15,11)
0332          CALL SYMBOL(4.2,7.5,.21,12HN=1.6 BARREL,0.0,+12)
0333          CALL PLOT(15.0,0.0,-3)
        C*****          OUTPUT FOR N=1.8 BARREL      *************
0334          WRITE(6,2)
0335        2 FORMAT('1','      ' ////////////////////// '0', 20X,
             *          'BARREL 2, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.0021
             1764*X**1.8,   N=1.8 BARREL')
0336          WRITE(6,410)
0337      410 FORMAT('1','BARREL 2, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.0021
             1764*X**1.8,   N=1.8 BARREL')
0338              WRITE(6,210)
0339          DO 260 J=1,NSET
0340          WRITE(6,200)J,IBDATA(J,2),BBL2(J,6),BBL2(J,4),BBL2(J,5),
             UBBL2(J,9),BBL2(J,10),IBDATA(J,1),BBL2(J,7),J
0341      260 CONTINUE
0342          WRITE(6,7)
0343          CALL FPLOT(NSET,1,IBDATA(1,2),  BBL2(1,4),0,SET,SET,SET,SET)
0344          WRITE(6,8)
0345          CALL FPLOT(NSET,1,IBDATA(1,1),  BBL2(1,4),0,SET,SET,SET,SET)
0346           CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),
             *          +35,YT,90.0,QFV,QDV)
0347          CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),
             *          -40,XP,0.0,PFV,PDV)
0348           CALL LINE(IBDATA(1,2),BBL2(1,4),NSET,1,15,11)
0349          CALL SYMBOL(4.2,7.5,.21,12HN=1.8 BARREL,0.0,+12)
0350          CALL LINE(IBDATA(1,2),BBL2(1,9),NSET,1,25,1)
0351          CALL LINE(IBDATA(1,2),BBL2(1,10),NSET,1,20,2)
0352          CALL AXIS(-.5,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),
             1+37,YT,90.0,BEARFV,BEARDV)
0353          CALL AXIS(-1.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),
             1+35,YT,90.0,SHRFV,SHRDV)
0354          CALL LEGEND(6.000,1.222)
0355          CALL PLOT(15.0,0.0,-3)
0356           CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),
             *          +35,YT,90.0,QFV,QDV)
0357          CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),
             *          -33,XT,0.0,TFV,TDV)
0358           CALL LINE( IBDATA(1,1),BBL2(1,4),NSET,1,15,11)
0359          CALL SYMBOL(4.2,7.5,.21,12HN=1.8 BARREL,0.0,+12)
0360          CALL PLOT(15.0,0.0,-3)
```

```
C*****          OUTPUT FOR N=2.0 BARREL      *************
      WRITE(6,3)
    3 FORMAT('1','      ' ////////////////////// '0', 20X,
     *          'BARREL 3, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.00066
     1696*X**2.0,    N=2.0 BARREL')
      WRITE(6,420)
  420 FORMAT('1','BARREL 3, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.00066
     1696*X**2.0,    N=2.0 BARREL')
          WRITE(6,210)
      DO 250 J=1,NSET
      WRITE(6,200)J,IBDATA(J,2),BBL3(J,6),BBL3(J,4),BBL3(J,5),
     0BBL3(J,9),BBL3(J,10),IBDATA(J,1),BBL3(J,7),J
  250 CONTINUE
      WRITE(6,7)
      CALL FPLOT(NSET,1,IBDATA(1,2),  BBL3(1,4),0,SET,SET,SET,SET)
      WRITE(6,8)
      CALL FPLOT(NSET,1,IBDATA(1,1),  BBL3(1,4),0,SET,SET,SET,SET)
       CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),
     *          +35,YT,90.0,QFV,QDV)
      CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),
     *          -40,XP,0.0,PFV,PDV)
       CALL LINE(IBDATA(1,2),BBL3(1,4),NSET,1,15,11)
      CALL SYMBOL(4.5,7.5,.21,12HN=2.0 BARREL,0.0,12)
      CALL AXIS(-1.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),
     1+35,YT,90.0,SHRFV,SHRDV)
      CALL AXIS(-.5,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),
     1+37,YT,90.0,BEARFV,BEARDV)
      CALL LINE(IBDATA(1,2),BBL3(1,10),NSET,1,20,2)
      CALL LINE(IBDATA(1,2),BBL3(1,9),NSET,1,25,1)
      CALL LEGEND(6.000,1.222)
      CALL PLOT(15.0,0.0,-3)
       CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),
     *          +35,YT,90.0,QFV,QDV)
      CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),
     *          -33,XT,0.0,TFV,TDV)
       CALL LINE( IBDATA(1,1),BBL3(1,4),NSET,1,15,11)
      CALL SYMBOL(4.2,7.5,.21,12HN=2.0 BARREL,0.0,+12)
      CALL PLOT(15.0,0.0,-3)
C*****          OUTPUT FOR RIA BARREL        *************
      WRITE(6,4)
    4 FORMAT('1','      ' ////////////////////// '0', 20X,
     *          'PRESENT RIA AMC 30 BARREL, 1IN FREE RUN, 11.75IN CONST
     1ANT EXIT AT 8.967 DEGREES,  RIA BARREL')
      WRITE(6,430)
  430 FORMAT('1','PRESENT RIA AMC 30 BARREL, 1IN FREE RUN, 11.75IN CONST
     1ANT EXIT AT 8.967 DEGREES,  RIA BARREL')
      WRITE(6,210)
      DO 460 J=1,NSET
      WRITE(6,200)J,IBDATA(J,2),BBLAMC(J,6),BBLAMC(J,4),BBLAMC(J,5),
     1BBLAMC(J,9),BBLAMC(J,10),IBDATA(J,1),BBLAMC(J,7),J
  460 CONTINUE
      WRITE(6,7)
      CALL FPLOT(NSET,1,IBDATA(1,2),BBLAMC(1,4),0,SET,SET,SET,SET)
```

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0398              WRITE(6,8)                                                    00005310
0399              CALL FPLOT(NSET,1,IBDATA(1,1),BBLAMC(1,4),0,SET,SET,SET,SET)  00005320
0400               CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),    00005330
                 @          +35,YT,90.0,QFV,QDV)                               00005340
0401               CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES), 00005350
                 @          -40,XP,0.0,PFV,PDV)                                00005360
0402               CALL LINE(IBDATA(1,2),BBLAMC(1,4),NSET,1,15,11)              00005370
0403              CALL SYMBOL(3.8,7.5,.21,10HRIA BARREL,0.0,+10)                00005380
0404              CALL LINE(IBDATA(1,2),BBLAMC(1,9),NSET,1,25,1)                00005390
0405              CALL LINE(IBDATA(1,2),BBLAMC(1,10),NSET,1,20,2)               00005400
0406              CALL AXIS(-1.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),    00005410
                 1+35,YT,90.0,SHRFV,SHRDV)                                      00005420
0407              CALL AXIS(-.5,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),   00005430
                 1+37,YT,90.0,BEARFV,BEARDV)                                    00005440
0408              CALL LEGEND(6.000,1.222)                                      00005450
0409              CALL PLOT(15.0,0.0,-3)                                        00005460
0410               CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),    00005470
                 @          +35,YT,90.0,QFV,QDV)                               00005480
0411              CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),       00005490
                 @          -33,XT,0.0,TFV,TDV)                                00005500
0412               CALL LINE(IBDATA(1,1),BBLAMC(1,4),NSET,1,15,11)              00005510
0413              CALL SYMBOL(3.8,7.5,.21,10HRIA BARREL,0.0,+10)                00005520
0414              CALL PLOT(15.0,0.0,-3)                                        00005530
C*****             OUTPUT FOR HERCULES BARREL     **********                  00005540
0415              WRITE(6,5)                                                    00005550
0416            5 FORMAT('1',' ' ////////////////////// '0', 20X,              00005560
                 @          'PRESENT HERCULES BARREL WITH 0. INITIAL ANGLE,8.9667 E00005570
                 1XIT ANG Y=.01008*X**1.5')                                     00005580
0417              WRITE(6,440)                                                  00005590
0418          440 FORMAT('1','PRESENT HERCULES BARREL WITH 0. INITIAL ANGLE,8.9667 E00005600
                 1XIT AND Y=.01008*X**1.5')                                     00005610
0419              WRITE(6,210)                                                  00005620
0420              DO 470 J=1,NSET                                               00005630
0421              WRITE(6,200)J,IBDATA(J,2),BBLHER(J,6),BBLHER(J,4),BBLHER(J,5), 00005640
                 1BBLHER(J,9),BBLHER(J,10),IBDATA(J-1),BBLHER(J,7),J            00005650
0422          470 CONTINUE                                                      00005660
0423              WRITE(6,7)                                                    00005670
0424              CALL FPLOT(NSET,1,IBDATA(1,2),BBLHER(1,4),0,SET,SET,SET,SET)  00005680
0425              WRITE(6,8)                                                    00005690
0426              CALL FPLOT(NSET,1,IBDATA(1,1),BBLHER(1,4),0,SET,SET,SET,SET)  00005700
0427               CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),    00005710
                 @          +35,YT,90.0,QFV,QDV)                               00005720
0428              CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES), 00005730
                 @          -40,XP,0.0,PFV,PDV)                                00005740
0429               CALL LINE(IBDATA(1,2),BBLHER(1,4),NSET,1,15,11)              00005750
0430              CALL SYMBOL(3.0,7.5,.21,15HHERCULES BARREL,0.0,+15)           00005760
0431              CALL LINE(IBDATA(1,2),BBLHER(1,9),NSET,1,25,1)                00005770
0432              CALL LINE(IBDATA(1,2),BBLHER(1,10),NSET,1,20,2)               00005780
0433              CALL AXIS(-1.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),    00005790
                 1+35,YT,90.0,SHRFV,SHRDV)                                      00005800
0434              CALL AXIS(-.5,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),   00005810
                 1+37,YT,90.0,BEARFV,BEARDV)                                    00005820
0435              CALL LEGEND(6.611,1.222)                                      00005830
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0436              CALL PLOT(15.0,0.0,-3)                                              00005840
0437               CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),          00005850
                 *          +35,YT,90.0,GFV,GDV)                                    00005860
0438              CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),            00005870
                 *          -33,XT,0.0,TFV,TDV)                                     00005880
0439               CALL LINE(IBDATA(1,1),BBLMER(1,4),NSET,1,15,11)                   00005890
0440              CALL SYMBOL(3.0,7.5,.21,15HMERCULES BARREL,0.0,+15)                00005900
0441              CALL PLOT(15.0,0.0,-3)                                              00005910
C*****             OUTPUT FOR CONSTANT TWIST BARREL   *******                       00005920
0442              WRITE(6,6)                                                          00005930
0443            6 FORMAT('1',' ' ////////////////////// '0', 20X,                    00005940
                 *          'CONSTANT TWIST BARREL')                                00005950
0444              WRITE(6,450)                                                        00005960
0445          450 FORMAT('1','CONSTANT TWIST BARREL')                                 00005970
0446              WRITE(6,210)                                                        00005980
0447              DO 480 J=1,NSET                                                     00005990
0448              WRITE(6,200)J,IBDATA(J,2),BBLCON(J,6),BBLCON(J,4),BBLCON(J,5),      00006000
                 1BBLCON(J,9),BBLCON(J,10),IBDATA(J,1),BBLCON(J,7),J                 00006010
0449          480 CONTINUE                                                            00006020
0450              WRITE(6,7)                                                          00006030
0451              CALL FPLOT(NSET,1,IBDATA(1,2),BBLCON(1,4),0,SET,SET,SET,SET)        00006040
0452              WRITE(6,8)                                                          00006050
0453              CALL FPLOT(NSET,1,IBDATA(1,1),BBLCON(1,4),0,SET,SET,SET,SET)        00006060
0454               CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),          00006070
                 *          +35,YT,90.0,GFV,GDV)                                    00006080
0455              CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),     00006090
                 *          -40,XP,0.0,PFV,PDV)                                     00006100
0456               CALL LINE(IBDATA(1,2),BBLCON(1,4),NSET,1,15,11)                   00006110
0457              CALL SYMBOL(3.0,7.5,.21,21HCONSTANT TWIST BARREL,0.0,+21)          00006120
0458              CALL LINE(IBDATA(1,2),BBLCON(1,10),NSET,1,20,2)                     00006130
0459              CALL LINE(IBDATA(1,2),BBLCON(1,9),NSET,1,25,1)                      00006140
0460              CALL AXIS(-1.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),          00006150
                 1+35,YT,90.0,SHFV,SHDV)                                             00006160
0461              CALL AXIS(-.5,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),         00006170
                 1+37,YT,90.0,BEARFV,BEARDV)                                         00006180
0462              CALL LEGEND(6.900,3.900)                                            00006190
0463              CALL PLOT(15.0,0.0,-3)                                              00006200
0464               CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),          00006210
                 *          +35,YT,90.0,GFV,GDV)                                    00006220
0465              CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),             00006230
                 *          -33,XT,0.0,TFV,TDV)                                     00006240
0466               CALL LINE(IBDATA(1,1),BBLCON(1,4),NSET,1,15,11)                   00006250
0467              CALL SYMBOL(3.0,7.5,.21,21HCONSTANT TWIST BARREL,0.0,+21)          00006260
0468              CALL PLOT(15.0,0.0,-3)                                              00006270
0469              CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),     00006280
                 *          -40,XP,0.0,PFV,PDV)                                     00006290
0470              CALL AXIS(0.0,0.0,37HBEARING STRESS ON ROTATING BAND (PSI),        00006300
                 1+37,YT,90.0,BEARFV,BEARDV)                                         00006310
0471              CALL LINE(IBDATA(1,2),BBLI(1,10),NSET,1,+20,4)                      00006320
0472              CALL LINE(IBDATA(1,2),BBLMER(1,10),NSET,1,+15,1)                    00006330
0473              CALL LINE(IBDATA(1,2),BBLCON(1,10),NSET,1,+25,5)                    00006340
0474              CALL LINE(IBDATA(1,2),BBLAMC(1,10),NSET,1,+30,9)                    00006350
0475              CALL SYMBOL(6.840,6.042,.07,10HRIA BARREL,0.0,+10)                  00006360
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0476              CALL SYMBOL(5.100,4.063,.07,12HN=1.6 BARREL,0.0,+12)                    00006370
0477              CALL SYMBOL(6.500,4.560,.07,15HHERCULES BARREL,0.0,+15)                 00006380
0478              CALL SYMBOL(6.701,2.500,.07,21HCONSTANT TWIST BARREL,0.0,+21)           00006390
0479              CALL SYMBOL(2.25,7.5,.21,27HBEARING STRESS COMPARISIONS,0.0,+27)        00006400
0480              CALL PLOT(15.0,0.0,-3)                                                  00006410
0481              CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),          00006420
                 1      -40,XP,0.0,PFV,PDV)                                             00006430
0482              CALL AXIS(0.0,0.0,35HSHEAR STRESS ON ROTATING BAND (PSI),              00006440
                 1+35,YT,90.0,SHRFV,SHRDV)                                               00006450
0483              CALL LINE(IBDATA(1,2),BBL1(1,9),NSET,1,+20,4)                           00006460
0484              CALL LINE(IBDATA(1,2),BBLHER(1,9),NSET,1,+15,1)                         00006470
0485              CALL LINE(IBDATA(1,2),BBLCON(1,9),NSET,1,+25,5)                         00006480
0486              CALL LINE(IBDATA(1,2),BBLAMC(1,9),NSET,1,+30,9)                         00006490
0487              CALL SYMBOL(6.840,6.458,.07,10HRIA BARREL,0.0,+10)                      00006500
0488              CALL SYMBOL(6.593,4.618,.07,12HN=1.6 BARREL,0.0,+12)                    00006510
0489              CALL SYMBOL(5.000,4.520,.07,15HHERCULES BARREL,0.0,+15)                 00006520
0490              CALL SYMBOL(6.632,2.604,.07,21HCONSTANT TWIST BARREL,0.0,+21)           00006530
0491              CALL SYMBOL(2.25,7.5,.21,25HSHEAR STRESS COMPARISIONS,0.0,+25)          00006540
0492            7 FORMAT('1',  'GRAPH OF TORQUE VS POSITION')                           00006550
0493            8 FORMAT('1',  'GRAPH OF TORQUE VS TIME')                               00006560
0494          200 FORMAT(' ',I3,2F9.3,F16.3,F16.4,2F16.2,F8.5,F13.3,I9)                  00006570
0495          210 FORMAT(' ',///,' ',' J  POSITION',5X,'Y',10X,'TORQUE',6X,' SHEAR AR00006580
                 AEA ',                                                                  00006590
                 13X,'SHEAR STRESS  BEARING STRESS    TIME     RIFLING ANGLE    J', 00006600
                 2/,' ',4X,'(INCHES)  (INCHES)',                                         00006610
                 25X,'(IN-LBS)',6X,'(INCHES**2)',6X,'(PSI)',10X,'(PSI)',                 00006620
                 46X,'(SECONDS)     (DEGREES)',///,' ')                                  00006630
0496              CALL TRAP(NSET,IBDATA(1,1),BBL1(1,4),SUM1TT)                            00006640
0497              CALL TRAP(NSET,IBDATA(1,1),BBL2(1,4),SUM2TT)                            00006650
0498              CALL TRAP(NSET,IBDATA(1,1),BBL3(1,4),SUM3TT)                            00006660
0499              CALL TRAP(NSET,IBDATA(1,1),BBLHER(1,4),SUMHTT)                          00006670
0500              CALL TRAP(NSET,IBDATA(1,1),BBLCON(1,4),SUMCTT)                          00006680
0501              CALL TRAP(NSET,IBDATA(1,1),BBLAMC(1,4),SUMATT)                          00006690
0502              CALL TRAP(NSET,IBDATA(1,1),BBL1(1,10),SUM1BT)                           00006700
0503              CALL TRAP(NSET,IBDATA(1,1),BBL2(1,10),SUM2BT)                           00006710
0504              CALL TRAP(NSET,IBDATA(1,1),BBL3(1,10),SUM3BT)                           00006720
0505              CALL TRAP(NSET,IBDATA(1,1),BBLHER(1,10),SUMHBT)                         00006730
0506              CALL TRAP(NSET,IBDATA(1,1),BBLCON(1,10),SUMCBT)                         00006740
0507              CALL TRAP(NSET,IBDATA(1,1),BBLAMC(1,10),SUMABT)                         00006750
0508              CALL TRAP(NSET,IBDATA(1,1),BBL1(1,9),SUM1ST)                            00006760
0509              CALL TRAP(NSET,IBDATA(1,1),BBL2(1,9),SUM2ST)                            00006770
0510              CALL TRAP(NSET,IBDATA(1,1),BBL3(1,9),SUM3ST)                            00006780
0511              CALL TRAP(NSET,IBDATA(1,1),BBLHER(1,9),SUMHST)                          00006790
0512              CALL TRAP(NSET,IBDATA(1,1),BBLCON(1,9),SUMCST)                          00006800
0513              CALL TRAP(NSET,IBDATA(1,1),BBLAMC(1,9),SUMAST)                          00006810
0514              CALL TRAP(NSET,IBDATA(1,2),BBL1(1,4),SUM1TP)                            00006820
0515              CALL TRAP(NSET,IBDATA(1,2),BBL2(1,4),SUM2TP)                            00006830
0516              CALL TRAP(NSET,IBDATA(1,2),BBL3(1,4),SUM3TP)                            00006840
0517              CALL TRAP(NSET,IBDATA(1,2),BBLHER(1,4),SUMHTP)                          00006850
0518              CALL TRAP(NSET,IBDATA(1,2),BBLCON(1,4),SUMCTP)                          00006860
0519              CALL TRAP(NSET,IBDATA(1,2),BBLAMC(1,4),SUMATP)                          00006870
0520              CALL TRAP(NSET,IBDATA(1,2),BBL1(1,10),SUM1BP)                           00006880
0521              CALL TRAP(NSET,IBDATA(1,2),BBL2(1,10),SUM2BP)                           00006890
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0522            CALL TRAP(NSET,IBDATA(1,2),BBL3(1,10),SUM3BP)                    00006900
0523            CALL TRAP(NSET,IBDATA(1,2),BBLHER(1,10),SUMHBP)                  00006910
0524            CALL TRAP(NSET,IBDATA(1,2),BBLCON(1,10),SUMCBP)                  00006920
0525            CALL TRAP(NSET,IBDATA(1,2),BBLAMC(1,10),SUMABP)                  00006930
0526            CALL TRAP(NSET,IBDATA(1,2),BBL1(1,9),SUM1SP)                     00006940
0527            CALL TRAP(NSET,IBDATA(1,2),BBL2(1,9),SUM2SP)                     00006950
0528            CALL TRAP(NSET,IBDATA(1,2),BBL3(1,9),SUM3SP)                     00006960
0529            CALL TRAP(NSET,IBDATA(1,2),BBLHER(1,9),SUMHSP)                   00006970
0530            CALL TRAP(NSET,IBDATA(1,2),BBLCON(1,9),SUMCSP)                   00006980
0531            CALL TRAP(NSET,IBDATA(1,2),BBLAMC(1,9),SUMASP)                   00006990
0532            WRITE(6,775)                                                     00007000
0533          775 FORMAT('1', /////////, '----------------------------------------00007010
               @--- INTEGRAL VALUES ----------------------------------------',00007020
               @ /, '********** TORQUE **********', 5X,                        00007030
               @      '********** SHEAR STRESS **********', 5X,                00007040
               @      '******** BEARING STRESS ********', /,                  00007050
               @      '    WRT TIME      WRT POSITION  ', 5X,                  00007060
               @      '    WRT TIME      WRT POSITION  ', 5X,                  00007070
               @      '    WRT TIME      WRT POSITION  ', /,                   00007080
               @      '  (IN-LB-SEC)      (IN-LB-IN)   ', 5X,                 00007090
               @      '    (PSI-SEC)        (PSI-IN)   ', 5X,                 00007100
               @      '    (PSI-SEC)        (PSI-IN)   ', //)                 00007110
0534            WRITE(6,776)SUM1TT,SUM1TP,SUM1ST,SUM1SP,SUM1BT,SUM1BP            00007120
0535          776 FORMAT(' ', 'N=1.6 BARREL', /, 3(E16.7,E16.7,5X),/)           00007130
0536            WRITE(6,777) SUM2TT,SUM2TP,SUM2ST,SUM2SP,SUM2BT,SUM2BP           00007140
0537          777 FORMAT(' ', 'N=1.8 BARREL', /, 3(E16.7,E16.7,5X),/)           00007150
0538            WRITE(6,778) SUM3TT,SUM3TP,SUM3ST,SUM3SP,SUM3BT,SUM3BP           00007160
0539          778 FORMAT(' ', 'N=2.0 BARREL', /, 3(E16.7,E16.7,5X),/)           00007170
0540            WRITE(6,779) SUMHTT,SUMHTP,SUMHST,SUMHSP,SUMHBT,SUMHBP           00007180
0541          779 FORMAT(' ', 'HERCULES BARREL', /, 3(E16.7,E16.7,5X),/)        00007190
0542            WRITE(6,780) SUMCTT,SUMCTP,SUMCST,SUMCSP,SUMCBT,SUMCBP           00007200
0543          780 FORMAT(' ', 'CONSTANT TWIST BARREL', /, 3(E16.7,E16.7,5X),/)  00007210
0544            WRITE(6,781) SUMATT,SUMATP,SUMAST,SUMASP,SUMABT,SUMABP           00007220
0545          781 FORMAT(' ', 'RIA BARREL', /, 3(E16.7,E16.7,5X),/)             00007230
0546            CALL FACTOR(1.0)                                                 00007235
0547            CALL PLOT(15.0,0.0,-3)                                           00007240
0548            CALL AXIS(0.0,0.0,40HPROJECTILE POSITION DOWN BARREL (INCHES),   00007250
               @          -40,XP,0.0,PFV,PDV)                                   00007260
0549            CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),        00007270
               1-35,YT,90.0,QFV,QDV)                                            00007280
0550            CALL LINE(IBDATA(1,2),BBL1(1,4),NSET,1,+20,0)                    00007290
0551            CALL LINE(IBDATA(1,2),BBL2(1,4),NSET,1,+20,2)                    00007300
0552            CALL LINE(IBDATA(1,2),BBL3(1,4),NSET,1,+20,4)                    00007310
0553            CALL LINE(IBDATA(1,2),BBLHER(1,4),NSET,1,+15,1)                  00007320
0554            CALL LINE(IBDATA(1,2),BBLCON(1,4),NSET,1,+25,5)                  00007330
0555            CALL LINE(IBDATA(1,2),BBLAMC(1,4),NSET,1,+30,9)                  00007340
0556            CALL SYMBOL(6.640,6.042,.07,10HRIA BARREL,0.0,+10)               00007350
0557            CALL SYMBOL(7.145,3.990,.07,12HN=1.6 BARREL,0.0,+12)             00007360
0558            CALL SYMBOL(7.100,4.351,.07,12HN=1.8 BARREL,0.0,+12)             00007370
0559            CALL SYMBOL(6.592,4.682,.07,12HN=2.0 BARREL,0.0,+12)             00007380
0560            CALL SYMBOL(6.018,3.541,.07,15HHERCULES BARREL,0.0,+15)          00007390
0561            CALL SYMBOL(2.365,6.835,.07,21HCONSTANT TWIST BARREL,0.0,+21)    00007400
0562            CALL SYMBOL(2.65,7.5,.21,27H        TORQUE COMPARISIONS,0.0,+27) 00007410
```

```
FORTRAN IV G LEVEL 21          MAIN          DATE = 75166          07/44/46

0563            CALL PLOT(15.0,0.0,-3)                                          00007420
0564            CALL AXIS(0.0,0.0,33HTIME FROM PRIMER STRIKE (SECONDS),         00007430
               @          -33,XP,0.0,TFV,TDV)                                  00007440
0565            CALL AXIS(0.0,0.0,35HTORQUE SPINNING PROJECTILE (IN-LBS),       00007450
               1*35,YT,90.0,QFV,QDV)                                           00007460
0566            CALL LINE(IBDATA(1,1),BBL1(1,4),NSET,1,+20,0)                   00007470
0567            CALL LINE(IBDATA(1,1),BBL2(1,4),NSET,1,+20,2)                   00007480
0568            CALL LINE(IBDATA(1,1),BBL3(1,4),NSET,1,+20,4)                   00007490
0569            CALL LINE(IBDATA(1,1),BBLHER(1,4),NSET,1,+15,1)                 00007500
0570            CALL LINE(IBDATA(1,1),BBLCON(1,4),NSET,1,+25,5)                 00007510
0571            CALL LINE(IBDATA(1,1),BBLAMC(1,4),NSET,1,+30,9)                 00007520
0572            CALL SYMBOL(6.910,7.100,.07,10HRIA BARREL,0.0,+10)              00007530
0573            CALL SYMBOL(7.390,3.910,.07,12HN=1.6 BARREL,0.0,+12)            00007540
0574            CALL SYMBOL(7.390,4.315,.07,12HN=1.8 BARREL,0.0,+12)            00007550
0575            CALL SYMBOL(7.390,4.625,.07,12HN=2.0 BARREL,0.0,+12)            00007560
0576            CALL SYMBOL(7.390,3.452,.07,15HHERCULES BARREL,0.0,+15)         00007570
0577            CALL SYMBOL(6.335,7.962,.07,21HCONSTANT TWIST BARREL,0.0,+21)   00007580
0578            CALL SYMBOL(1.75,7.5,.21,18HTORQUE COMPARISONS,0.0,+18)         00007590
0579            CALL PLOT(20.0,7.0,999)                                         00007600
0580            STOP                                                            00007610
0581            END                                                             00007620
```

```
      SUBROUTINE AAMC30(X,X1,X2,START,R,RHO,ABORE,PBASE,POLAR,APROJ,
     1Y,T,T1,T2,DYDX,D2YDX2,TORQUE,ALEFT,SHEAR,BEAR)
      B0=-1.26797E-04
      B1= 6.26041E-05
      B2= 1.49651E-03
      B3=-4.28221E-06
      B4= 8.61423E-09
      XX=X-START
      XX1=XX
      XX2=XX*XX
      XX3=XX*XX*XX
      XX4=XX*XX*XX*XX
      Y=B0+B1*XX1+B2*XX2+B3*XX3+B4*XX4
      T=Y/R
      DYDX=B1+2.*B2*XX1+3.*B3*XX2+4.*B4*XX3
      D2YDX2=2.*B2 +6.*B3*XX1+12.*B4*XX2
      T1=X1*DYDX/R
      T2=(X1*X1*D2YDX2+X2*DYDX)/R
      TORQUE=POLAR*T2
C       **** SHEAR AREA CALCULATION. AREA IS AREA SWEPT, ALEFT IS AREA
C       **** REMAINING ON THE ROTATING BAND PER SEGMENT
C       **** DRIVE IS DRIVING EDGE AREA
C       **** SUMFOR IS SUMMATION OF FORCES AT RADIUS TO PRODUCE TORQUE
      AREA=.0648000*DYDX
      ALEFT=(0.0334627-AREA)*20.0
      SUMFOR=TORQUE/R
      SHEAR=SUMFOR/ALEFT
      DRIVE=(.3600/COS(ATAN(DYDX)))*20.0*0.019
      BEAR=SUMFOR/DRIVE
      RETURN
      END
```

```
0001          SUBROUTINE CONST(SLOPE,END,X,X1,X2,AMT,R,RHO,ABORE,PHASE,Y,
             1T,T1,T2,TORQUE,ALEFT,DYDX,D2YDX2,SHEAR,BEAR)
        C
        C*****     CONSTANT TWIST CALCULATIONS                                  ***
        C
0002          POLAR=3.8043E-04
0003          Y=SLOPE*(X-END)+AMT
0004          T=Y/R
0005          T1=SLOPE*X1/R
0006          T2=SLOPE*X2/R
0007          TORQUE=POLAR*T2
0008          DYDX=SLOPE
0009          D2YDX2=0.0
        C       **** SHEAR AREA CALCULATION. AREA IS AREA SWEPT, ALEFT IS AREA
        C       **** REMAINING ON THE ROTATING BAND PER SEGMENT
        C       **** SUMFOR IS SUMMATION OF FORCES AT RADIUS TO PRODUCE TORQUE
        C       **** DRIVE IS DRIVING EDGE AREA
0010          SUMFOR=TORQUE/R
0011          ALEFT=0.03346267*20.0
0012          SHEAR=SUMFOR/ALEFT
0013          BEAR=SUMFOR/.1822270
0014          RETURN
0015          END
```

```
0001          SUBROUTINE FPLOT(N,M,X,Y,LCODE,XMIN,XMAX,YMIN,YMAX)                00008170
              C       SUBROUTINE FPLOT                                           00008180
              C  A SUBROUTINE USING THE LINE PRINTER TO PRODUCE A PLOT OF UP TO EIGHT 00008190
              C  ORDINATE ARRAYS VERSUS ONE ABSCISSA ARRAY.  FPLOT MAY BE USED WITH 00008200
              C  THE WATFIV COMPILER.                                            00008210
              C                                                                  00008220
              C  INPUT                                                           00008230
              C  N        INPUT INTEGER VALUE THAT SPECIFIES NUMBER OF VALUES OF X. 00008240
              C  M        INPUT INTEGER VALUE THAT SPECIFIES NUMBER OF SETS OF   00008250
              C           ORDINATES THAT ARE TO BE GRAPHED.  M MAY BE FROM 1 TO 8. 00008260
              C  X        INPUT N DIMENSIONAL REAL ARRAY CONTAINING VALUES OF ABSCISSA. 00008270
              C  Y        INPUT N BY M DIMENSIONAL REAL ARRAY.  EACH VALUE OF M  00008280
              C           SPECIFIES A SET OF ORDINATES.  EACH VALUE OF Y(I,M)    00008290
              C           SHOULD CORRESPOND TO ITS ABSCISSA VALUE, X(I), FOR I   00008300
              C           FROM 1 TO N.                                           00008310
              C  LCODE    IF LCODE=0, THE MINIMUMS AND MAXIMUMS OF THE SET OF VALUES 00008320
              C                       TO BE PLOTTED ARE FOUND FROM THE VALUES IN THE 00008330
              C                       X AND Y ARRAYS.                            00008340
              C           IF LCODE=1, THE USER SUPPLIES THESE VALUES IN THE      00008350
              C                       ARGUMENT LIST.                             00008360
              C  XMIN, XMAX, YMIN, YMAX                                          00008370
              C           THE MINIMUM AND MAXIMUM OF THE VALUES OF THE ABSCISSA  00008380
              C           AND MINIMUM AND MAXIMUM VALUES OF ALL THE ORDINATES.   00008390
0002            DIMENSION X(N),Y(N,M),XSCALE(11),YSCALE(6)                       00008400
0003            INTEGER*4 MARK(10)/'0','2','3','4','5','6','7','8','1','*'/,    00008410
               1LINE(101),DOT/'.'/,DASH/'-'/,BAR/'I'/,BLANK/' '/                 00008420
0004            IF(LCODE.EQ.1) GO TO 2                                           00008430
              C  DETERMINE THE MINIMUM AND MAXIMUM VALUES                        00008440
0005            XMIN=X(1)                                                        00008450
0006            XMAX=X(1)                                                        00008460
0007            YMIN=Y(1,1)                                                      00008470
0008            YMAX=Y(1,1)                                                      00008480
0009            DO 10 I=1,N                                                      00008490
0010            XMIN=AMIN1(XMIN,X(I))                                            00008500
0011       10   XMAX=AMAX1(XMAX,X(I))                                            00008510
0012            DO 20 I=1,N                                                      00008520
0013            DO 20 J=1,M                                                      00008530
0014            YMIN=AMIN1(YMIN,Y(I,J))                                          00008540
0015       20   YMAX=AMAX1(YMAX,Y(I,J))                                          00008550
              C  SCALE AND PLOT THE POINTS                                       00008560
0016       2    XINC=(XMAX-XMIN)/10.                                             00008570
0017            YINC=(YMAX-YMIN)/50.                                             00008580
0018            YMAXX=YMAX                                                       00008590
0019            XSCALE(1)=XMIN                                                   00008600
0020            DO 110 I=2,11                                                    00008610
0021       110  XSCALE(I)=XSCALE(I-1)+(XINC*10.)                                 00008620
0022            YSCALE(1)=YMAX                                                   00008630
0023            DO 120 I=2,6                                                     00008640
0024       120  YSCALE(I)=YSCALE(I-1)-(YINC*10.)                                 00008650
0025            LINECT=10                                                        00008660
0026            IF(M-1)150,150,160                                               00008670
0027       160  MARK(1)=MARK(9)                                                  00008680
0028       150  DO 1300 KI=1,51                                                  00008690
```

```
      DO 140 J=1,101
  140 LINE(J)=BLANK
      DO 161 K=1,M
      DO 161 L=1,N
      IF(Y(L,K).GT.YMAXX.OR.Y(L,K).LE.(YMAXX-YINC)) GO TO 161
      NXL=(X(L)-XMIN)/XINC+1
      IF(LINE(NXL).EQ.BLANK) GO TO 170
      IF(LINE(NXL).EQ.MARK(K)) GO TO 170
      LINE(NXL)=MARK(10)
      GO TO 161
  170 LINE(NXL)=MARK(K)
  161 CONTINUE
      YMAXX=YMAXX-YINC
      IF(LINECT-10)180,190,190
  190 LINECT=1
      WRITE(6,2001)  YSCALE((KI+10)/10),DASH,LINE
 2001 FORMAT(' ',F14.5,A1,101A1)
      GO TO 1300
  180 LINECT=LINECT+1
      WRITE(6,1100) DOT,LINE
 1100 FORMAT(' ',14X,A1,101A1)
 1300 CONTINUE
      DO 200 I=1,101
  200 LINE(I)=DOT
      DO 210 I=1,101,10
  210 LINE(I)=BAR
      WRITE(6,1500) LINE
 1500 FORMAT(' ',15X,101A1)
      WRITE(6,2002) (XSCALE(I),I=1,11,2)
 2002 FORMAT(' ',6(2X,F14.5,4X))
      WRITE(6,2003) (XSCALE(I),I=2,10,2)
 2003 FORMAT(' ',10X,5(2X,F14.5,4X))
      XINCH=XINC*10.
      YINCH=YINC*6.
      WRITE(6,9000) XINC,YINC
 9000 FORMAT('0',20X,'X-INCREMENT=',E15.6,20X,'Y-INCREMENT=',E15.6)
      WRITE(6,9001)XINCH,YINCH
 9001 FORMAT(' ',20X,'X-SCALE IS ',E16.6,' PER INCH',11X,'Y-SCALE IS ',
     1E16.6,' PER INCH')
      RETURN
      END
```

```
0001          SUBROUTINE GAINP(J,P,A,XP,T,T1,T2,TORQUE,ALEFT,Y,DYDX,
             1D2YDX2,SHEAR,BEAR,X,X1,X2,PBASE,START,R,APOLAR,APROJ,RHO,
             2ABORE)
        C
0002          XX=X+XP
0003          IF(XX.LE.0.0) GO TO 10
0004          Y=P*(XX**A)
0005          T=Y/R
0006          AN=A-1.0
0007          BN=ABS(A-2.0)
0008          DYDX=A*P*(XX**AN)
0009          D2YDX2=AN*A*P/(XX**BN)
0010          T1=DYDX*X1/R
0011          T2=(DYDX*X2+D2YDX2*X1*X1)/R
0012          TORQUE=APOLAR*T2
        C       **** SHEAR AREA CALCULATION. AREA IS AREA SWEPT, ALEFT IS AREA
        C       **** REMAINING ON THE ROTATING BAND PER SEGMENT
        C       **** SUMFOR IS SUMMATION OF FORCES AT RADIUS TO PRODUCE TORQUE
        C       **** DRIVE IS DRIVING EDGE AREA
0013          ASIDE=.3600/COS(ATAN(DYDX))
0014          BSIDE=0.360494
0015          CSIDE=0.3600*(DYDX-0.0524078)
0016          SSIDE=0.500*(ASIDE+BSIDE+CSIDE)
0017          QSIDE=SQRT(((SSIDE-ASIDE)*(SSIDE-BSIDE)*(SSIDE-CSIDE)/SSIDE))
0018          AREA=QSIDE*SSIDE
0019          ALEFT=(0.03346267-AREA)*20.0
0020          DRIVE=ASIDE*20.0*0.025
0021          SUMFOR=TORQUE/R
0022          SHEAR=SUMFOR/ALEFT
0023          BEAR=SUMFOR/DRIVE
0024          GO TO 40
0025       10 WRITE(6,20) J,A
0026       20 FORMAT(' ','*************    J=',I4,'        N=',F6.2,'    XX IS .LE.
             1ZERO')
0027       40 CONTINUE
0028          RETURN
0029          END
```

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```
FORTRAN IV G LEVEL  21                LEGEND              DATE = 75166          07/44/46

0001          SUBROUTINE LEGEND(XP,YPPP)                                          00009480
0002          YP=YPPP                                                             00009490
0003          SYMXP=XP-.28                                                        00009500
0004          SYMYP=YP+.07                                                        00009510
0005          CALL SYMBOL(SYMXP,SYMYP,.14,11,0.0,-1)                              00009520
0006          SYMXP=SYMXP-.21                                                     00009530
0007          CALL SYMBOL(SYMXP,SYMYP,.14,11,0.0,-4)                              00009540
0008          CALL SYMBOL(XP,YP,.14,6HTORQUE,0.0,6                                00009550
0009          YP=YP-.2                                                            00009560
0010          SYMYP=SYMYP-.2                                                      00009570
0011          CALL SYMBOL(SYMXP,SYMYP,.14,2,0.0,-1                                00009580
0012          SYMXP=SYMXP+.21                                                     00009590
0013          CALL SYMBOL(SYMXP,SYMYP,.14,2,0.0,-5)                               00009600
0014          CALL SYMBOL(XP,YP,.14,14HBEARING STRESS,0.0,14)                     00009610
0015          YP=YP-.2                                                            00009620
0016          SYMYP=SYMYP-.2                                                      00009630
0017          CALL SYMBOL(SYMXP,SYMYP,.14,1,0.0,-1)                               00009640
0018          SYMXP=SYMXP-.21                                                     00009650
0019          CALL SYMBOL(SYMXP,SYMYP,.14,1,0.0,-5)                               00009660
0020          CALL SYMBOL(XP,YP,.14,12HSHEAR STRESS,0.0,12)                       00009670
0021          RETURN                                                              00009680
0022          END                                                                 00009690
```

```
      SUBROUTINE LEGND1(XXX,YYY,NUM)
      XPAGE=XXX
      YPAGE=YYY
      SYMXP=XPAGE-.28
      SYMYP=YPAGE+.07
      IF(NUM   .EQ.2) GO TO 10
      CALL SYMBOL(SYMXP,SYMYP,.14, 5,0.0,-1)
      SYMXP=SYMXP-.21
      CALL SYMBOL(SYMXP,SYMYP,.14, 5,0.0,-4)
      CALL SYMBOL(XPAGE,YPAGE,.14,8HPOSITION,0.0,8)
      GO TO 11
   10 CONTINUE
      SYMXP=SYMXP-.21
   11 CONTINUE
      YPAGE=YPAGE-.2
      SYMYP=SYMYP-.2
      CALL SYMBOL(SYMXP,SYMYP,.14, 0,0.0,-1)
      SYMXP=SYMXP+.21
      CALL SYMBOL(SYMXP,SYMYP,.14, 0,0.0,-4)
      CALL SYMBOL(XPAGE,YPAGE,.14,8HVELOCITY,0.0,8)
      YPAGE=YPAGE-.2
      SYMYP=SYMYP-.2
      CALL SYMBOL(SYMXP,SYMYP,.14,11,0.0,-1)
      SYMXP=SYMXP-.21
      CALL SYMBOL(SYMXP,SYMYP,.14,11,0.0,-4)
      CALL SYMBOL(XPAGE,YPAGE,.14,12HACCELERATION,0.0,12)
      YPAGE=YPAGE-.2
      SYMYP=SYMYP-.2
      CALL SYMBOL(SYMXP,SYMYP,.14,12,0.0,-1)
      SYMXP=SYMXP+.21
      CALL SYMBOL(SYMXP,SYMYP,.14,12,0.0,-4)
      CALL SYMBOL(XPAGE,YPAGE,.14,8HPRESSURE,0.0,8)
      XPAGE=XXX
      YPAGE=YYY
      RETURN
      END
```

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```
FORTRAN IV G LEVEL  21                    TRAP                DATE = 75166          07/44/46

      SUBROUTINE TRAP(N,XX,YY,SUM)
      REAL XX(252),YY(252),XDUMMY(252),YDUMMY(252)
      DO 5 J=1,N
      XDUMMY(J)=XX(J)
      YDUMMY(J)=YY(J)
    5 CONTINUE
      SUM=0.0
      NTRAP=N-1
      NPTS=N-2
      DO 10 J=1,NTRAP
      DELTA=((YDUMMY(J)+YDUMMY(J+1))/2.0)*(XDUMMY(J+1)-XDUMMY(J))
      SUM=SUM+DELTA
   10 CONTINUE
      RETURN
      END
```

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BARREL AT 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.0064590E*X**1.6, N=1.6 BARREL

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CHANNEL 1 TO 3 SLOPE= INITIAL = -8.967 FAIL= Y=.0004590G*X**1.6, N=1.6 CHANNEL

J	POSITION (INCHES)	Y (INCHES)	TONGUE (IN-LBS)	SHEAR AREA (INCHES**2)	SHEAR STRESS (PSI)	BEARING STRESS (PSI)	TIME (SECONDS)	RIFLING ANGLE (DEGREES)	J
1	-4.692	0.0	0.0	**********	0.0	0.0	0.0	0.0	1
2	-4.594	0.0	0.0	**********	0.0	0.0	0.000010	0.0	2
3	-4.497	0.0	0.0	**********	0.0	0.0	0.000020	0.0	3
4	-4.399	0.0	0.0	**********	0.0	0.0	0.000030	0.0	4
5	-4.302	0.0	0.0	**********	0.0	0.0	0.000040	0.0	5
6	-4.205	0.0	0.0	**********	0.0	0.0	0.000050	0.0	6
7	-4.106	0.0	0.0	**********	0.0	0.0	0.000060	0.0	7
8	-4.008	0.0	0.0	**********	0.0	0.0	0.000070	0.0	8
9	-3.907	0.0	0.0	**********	0.0	0.0	0.000080	0.0	9
10	-3.809	0.0	0.0	**********	0.0	0.0	0.000090	0.0	10
11	-3.696	0.0	0.0	**********	0.0	0.0	0.000100	0.0	11
12	-3.582	0.0	0.0	**********	0.0	0.0	0.000110	0.0	12
13	-3.208	0.0	0.0	**********	0.0	0.0	0.000120	0.0	13
14	-2.937	0.0	0.0	**********	0.0	0.0	0.000130	0.0	14
15	-2.651	0.0	0.0	**********	0.0	0.0	0.000140	0.0	15
16	-2.354	0.0	0.0	**********	0.0	0.0	0.000150	0.0	16
17	-2.049	0.0	0.0	**********	0.0	0.0	0.000160	0.0	17
18	-1.738	0.0	0.0	**********	0.0	0.0	0.000170	0.0	18
19	-1.419	0.0	0.0	**********	0.0	0.0	0.000180	0.0	19
20	-1.096	0.0	0.0	**********	0.0	0.0	0.000190	0.0	20
21	-0.777	0.0	0.0	**********	0.0	0.0	0.00200	0.0	21
22	-0.455	0.0	0.0	**********	0.0	0.0	0.00210	0.0	22
23	-0.134	0.0	0.0	**********	0.0	0.0	0.00220	0.0	23
24	0.186	0.0	0.0	**********	0.0	0.0	0.00230	0.0	24
25	0.503	0.0	0.0	**********	0.0	0.0	0.00240	0.0	25
26	0.816	0.0	0.0	**********	0.0	0.0	0.00250	0.0	26
27	1.124	0.503	-0.667	0.6664	-1.001	-62.68	0.00260	3.015	27
28	1.425	0.519	-14.312	0.6681	-21.427	-124.80	0.00270	3.050	28
29	1.719	0.535	-21.500	0.6671	-32.244	-201.56	0.00280	3.096	29
30	2.002	0.550	-31.862	0.6658	-47.851	-294.00	0.00290	3.117	30
31	2.271	0.565	-42.903	0.6659	-64.440	-402.12	0.00300	3.143	31
32	2.525	0.579	-55.900	0.6652	-84.010	-524.88	0.00310	3.177	32
33	2.759	0.592	-69.932	0.6646	-105.161	-655.62	0.00320	3.204	33
34	2.970	0.604	-84.329	0.6641	-126.959	-790.46	0.00330	3.226	34
35	3.154	0.614	-98.629	0.6636	-148.636	-920.79	0.00340	3.248	35
36	3.310	0.623	-110.494	0.6632	-166.654	-1035.67	0.00350	3.266	36
37	3.433	0.630	-119.847	0.6629	-180.804	-1123.73	0.00360	3.280	37
38	3.523	0.635	-125.054	0.6627	-188.705	-1172.12	0.00370	3.290	38
39	3.579	0.638	-124.655	0.6626	-188.100	-1168.37	0.00380	3.294	39
40	3.600	0.640	-117.572	0.6625	-177.411	-1101.98	0.00390	3.294	40
41	3.595	0.639	-104.711	0.6626	-157.953	-981.03	0.00400	3.289	41
42	3.600	0.651	0.0	0.6620	0.0	0.0	0.00515	3.320	42
43	3.600	0.651	0.0	0.6620	0.0	0.0	0.00540	3.320	43
44	3.600	0.651	0.0	0.6620	0.0	0.0	0.00570	3.320	44
45	3.600	0.651	0.0	0.6620	0.0	0.0	0.00600	3.320	45
46	3.600	0.651	0.0	0.6620	0.0	0.0	0.00630	3.320	46
47	3.600	0.651	0.0	0.6620	0.0	0.0	0.00660	3.320	47
48	3.600	0.651	0.0	0.6620	0.0	0.0	0.00690	3.320	48
49	3.600	0.651	0.0	0.6620	0.0	0.0	0.00720	3.320	49
50	3.600	0.651	0.0	0.6620	0.0	0.0	0.00750	3.320	50
51	3.600	0.651	0.0	0.6620	0.0	0.0	0.00780	3.320	51
52	3.600	0.651	0.0	0.6620	0.0	0.0	0.00810	3.320	52

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53	3.400	0.651	0.0	0.0620	0.0	0.0	0.00840	3.320	53
54	3.400	0.651	0.0	0.0620	0.0	0.0	0.00870	3.320	54
55	3.400	0.651	0.0	0.0620	0.0	0.0	0.00900	3.320	55
56	3.400	0.651	0.0	0.0620	0.0	0.0	0.00930	3.320	56
57	3.400	0.651	0.0	0.0620	0.0	0.0	0.00960	3.320	57
58	3.400	0.651	0.0	0.0620	0.0	0.0	0.00990	3.320	58
59	3.400	0.651	0.0	0.0620	0.0	0.0	0.01020	3.320	59
60	3.400	0.651	0.0	0.0620	0.0	0.0	0.01050	3.320	60
61	3.400	0.651	0.0	0.0620	0.0	0.0	0.01080	3.320	61
62	3.400	0.651	0.0	0.0620	0.0	0.0	0.01110	3.320	62
63	3.400	0.651	0.0	0.0620	0.0	0.0	0.01140	3.320	63
64	3.400	0.651	0.0	0.0620	0.0	0.0	0.01170	3.320	64
65	3.400	0.651	0.0	0.0620	0.0	0.0	0.01200	3.320	65
66	3.400	0.651	215.697	0.0620	550.63	2021.64	0.01203	3.320	66
67	3.401	0.661	404.819	0.0619	1033.54	3792.26	0.01206	3.338	67
68	4.102	0.664	574.088	0.0612	1467.15	5380.32	0.01209	3.354	68
69	4.232	0.675	725.040	0.0609	1853.90	6795.18	0.01212	3.368	69
70	4.361	0.684	858.849	0.0606	2197.23	8049.57	0.01215	3.382	70
71	4.495	0.692	977.209	0.0603	2501.15	9158.27	0.01218	3.397	71
72	4.640	0.701	1081.645	0.0599	2769.96	10136.85	0.01222	3.413	72
73	4.803	0.710	1173.864	0.0595	3007.95	11000.90	0.01225	3.430	73
74	4.987	0.721	1255.457	0.0590	3219.26	11765.40	0.01228	3.450	74
75	5.195	0.734	1327.939	0.0585	3407.72	12444.27	0.01231	3.473	75
76	5.431	0.749	1392.430	0.0580	3576.85	13050.14	0.01234	3.498	76
77	5.695	0.765	1450.737	0.0573	3729.73	13594.25	0.01237	3.526	77
78	5.971	0.781	1503.311	0.0566	3869.09	14086.41	0.01240	3.557	78
79	6.261	0.798	1551.253	0.0558	3997.25	14535.10	0.01243	3.592	79
80	6.568	0.815	1595.335	0.0550	4116.21	14947.52	0.01246	3.630	80
81	7.075	0.851	1636.213	0.0540	4227.68	15329.85	0.01249	3.671	81
82	7.501	0.879	1674.444	0.0530	4333.06	15687.25	0.01252	3.714	82
83	7.959	0.903	1710.494	0.0520	4433.57	16024.14	0.01255	3.761	83
84	8.450	0.921	1744.772	0.0508	4530.27	16344.31	0.01259	3.811	84
85	8.972	0.939	1777.615	0.0497	4624.00	16650.96	0.01262	3.863	85
86	9.526	1.014	1809.324	0.0484	4715.55	16946.86	0.01265	3.918	86
87	10.107	1.054	1840.155	0.0471	4805.57	17234.45	0.01268	3.976	87
88	10.719	1.097	1870.329	0.0457	4894.62	17515.77	0.01271	4.035	88
89	11.359	1.142	1900.037	0.0443	4983.21	17792.63	0.01274	4.097	89
90	12.027	1.191	1929.436	0.0429	5071.72	18066.42	0.01277	4.161	90
91	12.722	1.242	1958.641	0.0414	5160.49	18338.40	0.01280	4.227	91
92	13.443	1.295	987.759	0.0399	5249.75	18609.37	0.01283	4.294	92
93	14.190	1.352	2016.852	0.0383	5339.65	18879.65	0.01286	4.363	93
94	14.962	1.411	2045.988	0.0367	5430.24	19150.02	0.01289	4.434	94
95	15.758	1.473	2074.905	0.0350	5521.48	19419.73	0.01292	4.508	95
96	16.576	1.539	2103.812	0.0334	5613.17	19688.29	0.01295	4.585	96
97	17.421	1.607	2132.911	0.0317	5705.05	19954.75	0.01299	4.664	97
98	18.288	1.679	2160.965	0.0299	5796.77	20217.88	0.01302	4.746	98
99	19.177	1.752	2188.678	0.0282	5887.77	20475.82	0.01305	4.829	99
100	20.090	1.829	2215.731	0.0264	5977.48	20726.51	0.01308	4.914	100
101	21.026	1.910	2241.765	0.0246	6065.17	20967.54	0.01311	5.001	101
102	21.980	1.994	2266.468	0.0228	6150.04	21196.18	0.01314	5.044	102
103	22.955	2.081	2289.601	0.0209	6231.25	21409.64	0.01317	5.125	103
104	23.955	2.171	2310.769	0.0191	6307.83	21604.79	0.01320	5.207	104
105	24.978	2.265	2329.609	0.0172	6378.71	21778.05	0.01323	5.290	105
106	26.020	2.362	2345.867	0.0153	6443.01	21926.67	0.01326	5.373	106
107	27.082	2.463	2359.046	0.0134	6499.64	22047.15	0.01329	5.458	107
108	28.165	2.567	2368.933	0.0114	6547.59	22136.39	0.01332	5.543	108
109	29.266	2.675	2375.187	0.0095	6585.93	22191.61	0.01336	5.628	109
110	30.388	2.786	2377.533	0.0075	6613.80	22210.20	0.01339	5.714	110
111	31.528	2.901	2375.799	0.0055	6630.34	22199.77	0.01342	5.801	111
112	32.685	3.019	2369.540	0.0035	6634.95	22126.71	0.01345	5.888	112

113	33.861	3.142	2358.859	0.6015	6627.02	22025.44 0.01348	5.976	113
114	35.052	3.267	2343.612	0.5995	6606.27	21879.56 0.01351	6.064	114
115	36.259	3.396	2323.630	0.5975	6572.61	21691.30 0.01354	6.152	115
116	37.481	3.529	2299.516	0.5955	6525.93	21460.75 0.01357	6.240	116
117	38.717	3.665	2270.825	0.5934	6466.50	21189.39 0.01360	6.329	117
118	39.966	3.805	2236.072	0.5914	6395.07	20880.17 0.01363	6.417	118
119	41.228	3.947	2201.510	0.5894	6312.23	20535.46 0.01366	6.506	119
120	42.497	4.091	2161.481	0.5874	6218.84	20158.51 0.01369	6.594	120
121	43.778	4.242	2118.577	0.5853	6116.47	19754.83 0.01372	6.682	121
122	45.066	4.394	2073.247	0.5833	6006.32	19328.64 0.01376	6.770	122
123	46.366	4.550	2026.164	0.5813	5890.13	18885.86 0.01379	6.858	123
124	47.671	4.708	1977.811	0.5793	5769.61	18432.12 0.01382	6.946	124
125	48.982	4.868	1929.139	0.5773	5647.12	17975.17 0.01385	7.033	125
126	50.299	5.032	1880.728	0.5753	5524.48	17520.80 0.01388	7.119	126
127	51.621	5.198	1833.258	0.5733	5403.80	17075.71 0.01391	7.206	127
128	52.944	5.367	1787.619	0.5713	5287.37	16647.07 0.01394	7.292	128
129	54.279	5.539	1744.367	0.5694	5177.32	16241.36 0.01397	7.377	129
130	55.615	5.712	1704.201	0.5674	5075.50	15864.13 0.01400	7.462	130
131	56.956	5.888	1667.584	0.5655	4983.57	15520.26 0.01403	7.547	131
132	58.302	6.066	1635.290	0.5635	4903.90	15216.70 0.01406	7.631	132
133	59.653	6.250	1607.357	0.5616	4836.76	14953.82 0.01409	7.716	133
134	61.011	6.435	1584.198	0.5597	4783.52	14735.42 0.01412	7.799	134
135	62.376	6.623	1565.781	0.5577	4744.24	14561.20 0.01416	7.883	135
136	63.750	6.814	1552.137	0.5558	4719.19	14431.38 0.01419	7.966	136
137	65.132	7.009	1542.725	0.5539	4706.86	14340.93 0.01422	8.050	137
138	66.525	7.207	1537.472	0.5520	4707.20	14289.14 0.01425	8.133	138
139	67.928	7.408	1535.157	0.5500	4716.70	14265.01 0.01428	8.217	139
140	69.343	7.614	1534.957	0.5481	4732.56	14259.77 0.01431	8.300	140
141	70.771	7.823	1536.289	0.5462	4753.44	14269.09 0.01434	8.384	141
142	72.211	8.036	1536.781	0.5442	4771.87	14270.56 0.01437	8.468	142
143	73.662	8.253	1535.376	0.5423	4784.55	14254.40 0.01440	8.552	143
144	75.122	8.474	1529.917	0.5404	4784.64	14200.58 0.01443	8.635	144
145	76.589	8.698	1518.740	0.5384	4766.75	14093.70 0.01446	8.719	145
146	78.060	8.925	1499.376	0.5365	4722.86	13910.89 0.01449	8.802	146
147	79.525	9.153	1469.844	0.5346	4646.37	13633.85 0.01453	8.884	147
148	80.982	9.381	1428.217	0.5327	4530.74	13244.78 0.01456	8.966	148
149	82.416	9.608	85.285	0.5327	412.87	800.66 0.01459	8.967	149
150	83.814	9.828	19.379	0.5327	48.37	181.93 0.01462	8.967	150
151	85.160	10.041	-61.818	0.5327	-154.30	-580.35 0.01465	8.967	151

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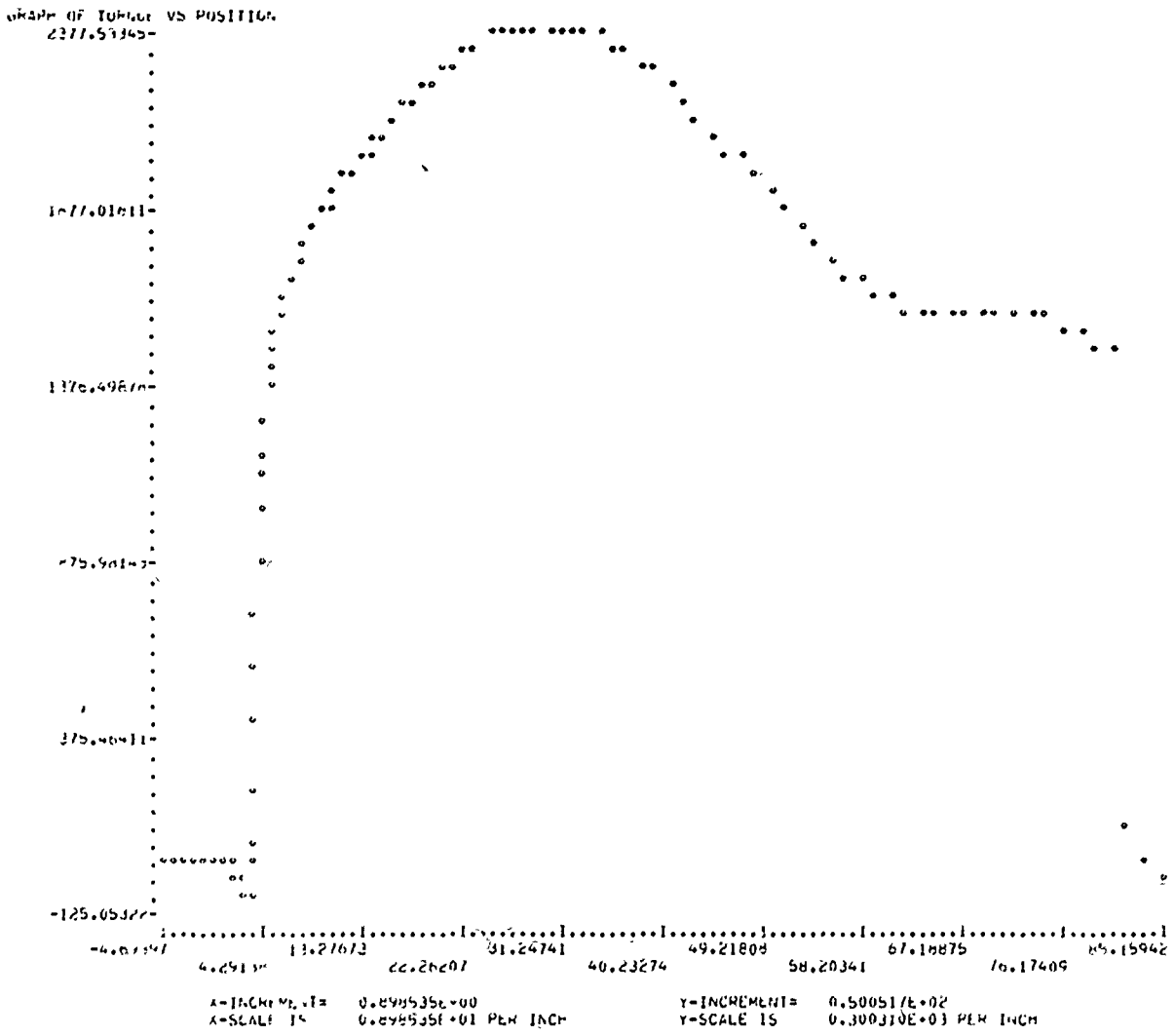

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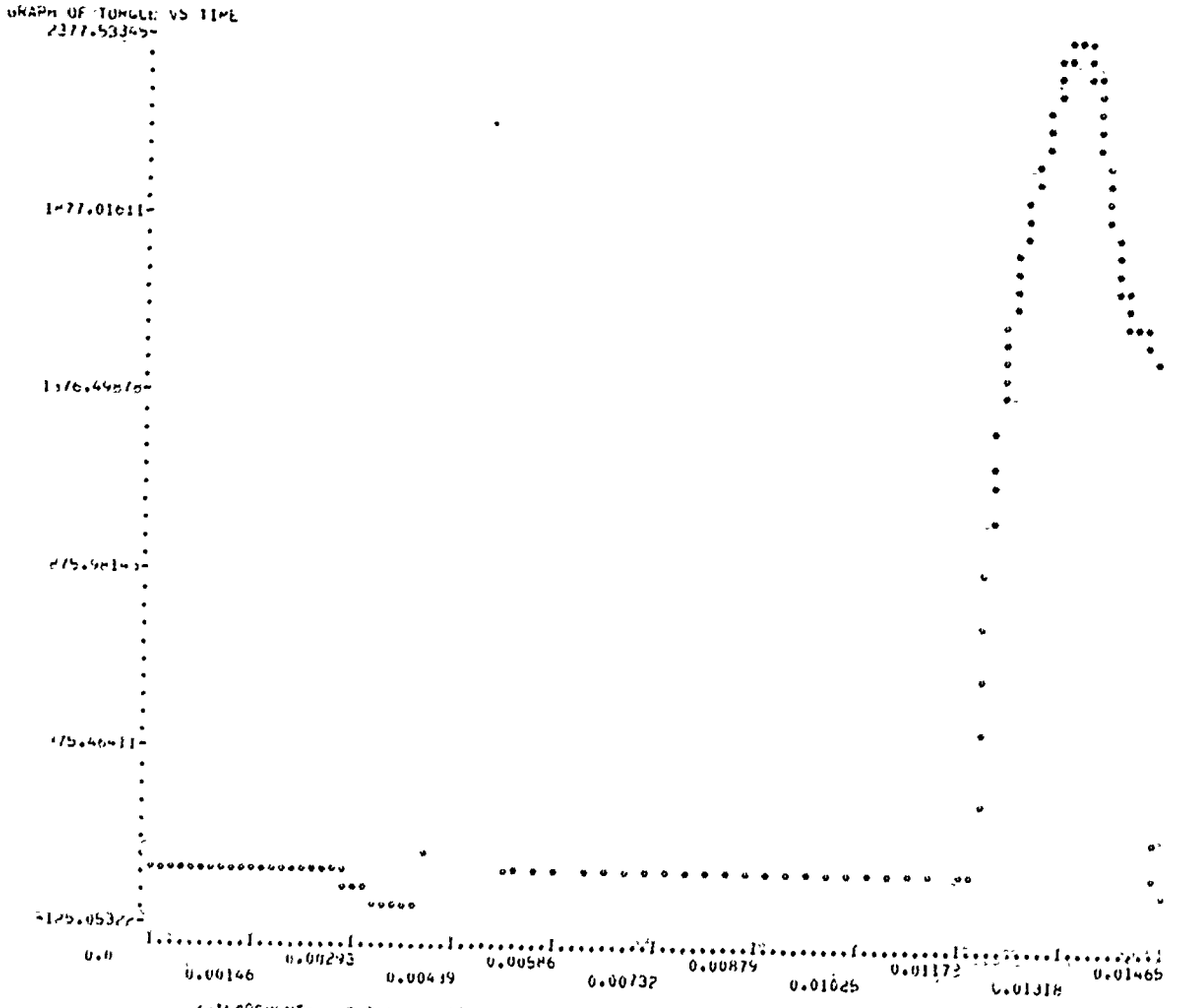

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BARREL 2, 3 DEGREE INITIAL ANGLE, R.967 EXIT, Y=.00210764*X**1.8, N=1.8 BARREL

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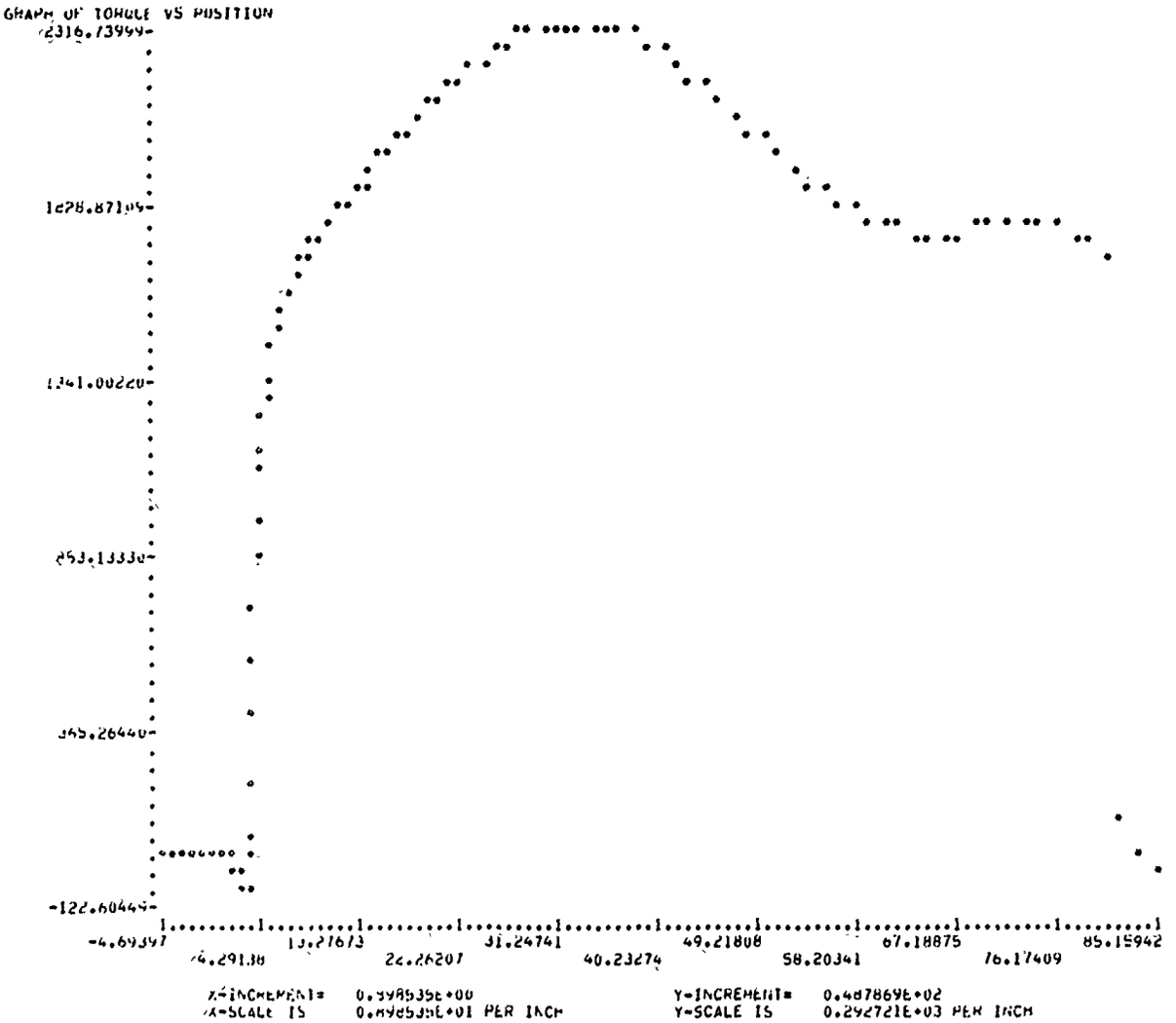
BARREL 2. 5 DEGREE INITIAL ANGLE= 0.967 RATE= r=.00210764*x**1.8. N=1.8 BARREL

J	POSITION (INCHES)	Y (INCHES)	TORQUE (IN-LBS)	SHEAR AREA (INCHES**2)	SHEAR STRESS (PSI)	BEARING STRESS (PSI)	TIME (SECONDS)	RIFLING ANGLE (DEGREES)	J
1	-4.692	0.0	0.0	**********	0.0	0.0	0.0	0.0	1
2	-4.694	0.0	0.0	**********	0.0	0.0	0.00010	0.0	2
3	-4.675	0.0	0.0	**********	0.0	0.0	0.00020	0.0	3
4	-4.645	0.0	0.0	**********	0.0	0.0	0.00030	0.0	4
5	-4.587	0.0	0.0	**********	0.0	0.0	0.00040	0.0	5
6	-4.505	0.0	0.0	**********	0.0	0.0	0.00050	0.0	6
7	-4.397	0.0	0.0	**********	0.0	0.0	0.00060	0.0	7
8	-4.260	0.0	0.0	**********	0.0	0.0	0.00070	0.0	8
9	-4.097	0.0	0.0	**********	0.0	0.0	0.00080	0.0	9
10	-3.909	0.0	0.0	**********	0.0	0.0	0.00090	0.0	10
11	-3.696	0.0	0.0	**********	0.0	0.0	0.00100	0.0	11
12	-3.462	0.0	0.0	**********	0.0	0.0	0.00110	0.0	12
13	-3.208	0.0	0.0	**********	0.0	0.0	0.00120	0.0	13
14	-2.937	0.0	0.0	**********	0.0	0.0	0.00130	0.0	14
15	-2.651	0.0	0.0	**********	0.0	0.0	0.00140	0.0	15
16	-2.354	0.0	0.0	**********	0.0	0.0	0.00150	0.0	16
17	-2.049	0.0	0.0	**********	0.0	0.0	0.00160	0.0	17
18	-1.736	0.0	0.0	**********	0.0	0.0	0.00170	0.0	18
19	-1.419	0.0	0.0	**********	0.0	0.0	0.00180	0.0	19
20	-1.098	0.0	0.0	**********	0.0	0.0	0.00190	0.0	20
21	-0.777	0.0	0.0	**********	0.0	0.0	0.00200	0.0	21
22	-0.455	0.0	0.0	**********	0.0	0.0	0.00210	0.0	22
23	-0.134	0.0	0.0	**********	0.0	0.0	0.00220	0.0	23
24	0.186	0.0	0.0	**********	0.0	0.0	0.00230	0.0	24
25	0.503	0.0	0.0	**********	0.0	0.0	0.00240	0.0	25
26	0.818	0.0	0.0	**********	0.0	0.0	0.00250	0.0	26
27	1.129	.742	-9.744	0.6690	-24.61	-91.36	0.00260	3.011	27
28	1.429	0.803	-16.074	0.6684	-40.64	-150.70	0.00270	3.038	28
29	1.719	0.823	-23.905	0.6678	-60.49	-224.11	0.00280	3.064	29
30	2.002	0.839	-33.340	0.6672	-84.44	-312.56	0.00290	3.089	30
31	2.271	0.853	-44.381	0.6667	-112.49	-416.05	0.00300	3.112	31
32	2.525	0.867	-56.807	0.6662	-144.10	-532.53	0.00310	3.135	32
33	2.759	0.880	-70.213	0.6657	-178.23	-658.18	0.00320	3.155	33
34	2.970	0.892	-83.952	0.6653	-213.24	-786.96	0.00330	3.174	34
35	3.154	0.902	-97.207	0.6649	-247.04	-911.20	0.00340	3.190	35
36	3.310	0.910	-108.966	0.6648	-276.81	-1020.50	0.00350	3.203	36
37	3.433	0.917	-117.774	0.6644	-299.56	-1103.96	0.00360	3.214	37
38	3.523	0.922	-122.605	0.6642	-311.93	-1149.24	0.00370	3.222	38
39	3.579	0.924	-122.075	0.6641	-310.63	-1144.26	0.00380	3.227	39
40	3.602	0.927	-115.087	0.6641	-292.87	-1078.76	0.00390	3.229	40
41	3.595	0.927	26.108	0.6641	66.44	244.72	0.00400	3.228	41
42	3.600	0.934	0.0	0.6637	0.0	0.0	0.00515	3.246	42
43	3.600	0.934	0.0	0.6637	0.0	0.0	0.00540	3.246	43
44	3.600	0.934	0.0	0.6637	0.0	0.0	0.00570	3.246	44
45	3.600	0.934	0.0	0.6637	0.0	0.0	0.00600	3.246	45
46	3.600	0.934	0.0	0.6637	0.0	0.0	0.00630	3.246	46
47	3.600	0.934	0.0	0.6637	0.0	0.0	0.00660	3.246	47
48	3.600	0.934	0.0	0.6637	0.0	0.0	0.00690	3.246	48
49	3.600	0.934	0.0	0.6637	0.0	0.0	0.00720	3.246	49
50	3.600	0.934	0.0	0.6637	0.0	0.0	0.00750	3.246	50
51	3.600	0.934	0.0	0.6637	0.0	0.0	0.00780	3.246	51
52	3.600	0.934	0.0	0.6637	0.0	0.0	0.00810	3.246	52

53	3.800	0.938	0.0	0.6637	0.0	0.0	0.00840	3.246	53
54	3.800	0.938	0.0	0.6637	0.0	0.0	0.00870	3.246	54
55	3.800	0.938	0.0	0.6637	0.0	0.0	0.00900	3.246	55
56	3.800	0.938	0.0	0.6637	0.0	0.0	0.00930	3.246	56
57	3.800	0.938	0.0	0.6637	0.0	0.0	0.00960	3.246	57
58	3.800	0.938	0.0	0.6637	0.0	0.0	0.00990	3.246	58
59	3.800	0.938	0.0	0.6637	0.0	0.0	0.01020	3.246	59
60	3.800	0.938	0.0	0.6637	0.0	0.0	0.01050	3.246	60
61	3.800	0.938	0.0	0.6637	0.0	0.0	0.01080	3.246	61
62	3.800	0.938	0.0	0.6637	0.0	0.0	0.01110	3.246	62
63	3.800	0.938	0.0	0.6637	0.0	0.0	0.01140	3.246	63
64	3.800	0.938	0.0	0.6637	0.0	0.0	0.01180	3.246	64
65	3.800	0.938	0.0	0.6637	0.0	0.0	0.01200	3.246	65
66	3.800	0.938	210.854	0.6637	536.91	1976.43	0.01203	3.246	66
67	3.961	0.947	395.115	0.6634	1006.56	3703.47	0.01206	3.260	67
68	4.102	0.955	560.006	0.6631	1427.22	5248.95	0.01209	3.272	68
69	4.232	0.963	706.513	0.6628	1801.31	6622.11	0.01212	3.284	69
70	4.361	0.970	835.927	0.6626	2132.07	7835.00	0.01215	3.295	70
71	4.495	0.978	949.717	0.6623	2423.26	8901.43	0.01218	3.306	71
72	4.640	0.986	1049.440	0.6620	2678.87	9835.96	0.01222	3.319	72
73	4.803	0.994	1136.664	0.6617	2902.94	10653.39	0.01225	3.333	73
74	4.987	1.004	1212.928	0.6613	3099.39	11367.95	0.01228	3.349	74
75	5.195	1.019	1279.663	0.6609	3271.93	11993.19	0.01231	3.367	75
76	5.431	1.031	1338.219	0.6605	3424.04	12541.72	0.01234	3.387	76
77	5.696	1.044	1389.814	0.6599	3558.85	13024.96	0.01237	3.410	77
78	5.993	1.056	1435.557	0.6594	3679.19	13453.29	0.01240	3.436	78
79	6.321	1.068	1476.429	0.6587	3787.61	13835.91	0.01243	3.464	79
80	6.681	1.108	1513.291	0.6580	3886.31	14180.89	0.01246	3.495	80
81	7.075	1.132	1546.910	0.6573	3977.25	14495.41	0.01249	3.528	81
82	7.501	1.158	1577.953	0.6564	4062.15	14785.73	0.01252	3.564	82
83	7.959	1.187	1606.996	0.6556	4142.49	15057.22	0.01255	3.603	83
84	8.450	1.218	1634.549	0.6546	4219.58	15314.68	0.01259	3.645	84
85	8.972	1.252	1661.043	0.6536	4294.54	15562.15	0.01262	3.689	85
86	9.524	1.287	1686.465	0.6526	4368.35	15803.24	0.01265	3.735	86
87	10.107	1.324	1712.334	0.6515	4441.86	16040.95	0.01268	3.784	87
88	10.719	1.366	1737.728	0.6503	4515.78	16277.87	0.01271	3.835	88
89	11.359	1.410	1763.285	0.6491	4590.74	16516.23	0.01274	3.888	89
90	12.027	1.455	1789.176	0.6478	4667.20	16757.64	0.01277	3.944	90
91	12.722	1.504	1815.557	0.6465	4745.57	17003.55	0.01280	4.001	91
92	13.443	1.554	1842.567	0.6452	4826.14	17254.87	0.01283	4.061	92
93	14.190	1.606	1870.142	0.6438	4909.06	17512.15	0.01286	4.122	93
94	14.962	1.664	1898.419	0.6423	4994.40	17775.51	0.01289	4.185	94
95	15.758	1.723	1927.345	0.6409	5082.15	18044.85	0.01292	4.250	95
96	16.578	1.784	1956.832	0.6394	5172.10	18319.33	0.01295	4.316	96
97	17.421	1.848	1986.775	0.6378	5263.98	18597.97	0.01299	4.384	97
98	18.286	1.915	2017.032	0.6362	5357.46	18879.42	0.01302	4.454	98
99	19.177	1.985	2047.397	0.6346	5451.99	19161.78	0.01305	4.525	99
100	20.090	2.059	2077.649	0.6330	5547.01	19442.95	0.01308	4.597	100
101	21.024	2.134	2107.518	0.6313	5641.80	19720.39	0.01311	4.672	101
102	21.980	2.212	2136.711	0.6296	5735.58	19991.39	0.01314	4.747	102
103	22.954	2.294	2164.921	0.6278	5827.52	20255.04	0.01317	4.824	103
104	23.958	2.379	2191.799	0.6260	5916.69	20502.10	0.01320	4.902	104
105	24.978	2.468	2216.963	0.6242	6002.01	20734.99	0.01323	4.982	105
106	26.020	2.559	2240.102	0.6224	6082.62	20948.81	0.01326	5.063	106
107	27.082	2.654	2260.824	0.6205	6157.42	21139.90	0.01329	5.145	107
108	28.165	2.752	2278.780	0.6186	6225.39	21304.98	0.01332	5.228	108
109	29.266	2.854	2293.643	0.6167	6285.58	21441.02	0.01336	5.313	109
110	30.388	2.959	2305.105	0.6147	6337.06	21545.15	0.01339	5.398	110
111	31.528	3.068	2312.877	0.6127	6378.95	21614.68	0.01342	5.485	111
112	32.685	3.180	2316.740	0.6107	6410.54	21647.57	0.01345	5.573	112

113	33.881	3.295	2316.479	0.6087	6431.11	21641.84	0.01348	5.661	113
114	35.052	3.414	2311.995	0.6067	6440.27	21596.59	0.01351	5.751	114
115	36.259	3.537	2303.253	0.6046	6437.80	21511.49	0.01354	5.841	115
116	37.481	3.663	2290.201	0.6025	6423.40	21386.04	0.01357	5.932	116
117	38.717	3.792	2272.927	0.6004	6397.18	21221.23	0.01360	6.023	117
118	39.966	3.925	2251.577	0.5983	6359.70	21019.24	0.01363	6.116	118
119	41.228	4.061	2226.637	0.5962	6311.33	20781.86	0.01366	6.206	119
120	42.497	4.200	2198.082	0.5941	6252.73	20511.70	0.01369	6.301	120
121	43.774	4.343	2166.533	0.5919	6185.25	20213.64	0.01372	6.395	121
122	45.065	4.488	2132.375	0.5898	6109.86	19891.26	0.01376	6.488	122
123	46.366	4.637	2096.162	0.5876	6028.14	19549.99	0.01379	6.582	123
124	47.671	4.787	2058.504	0.5855	5941.56	19194.93	0.01382	6.676	124
125	48.982	4.943	2020.162	0.5833	5852.33	18833.37	0.01385	6.770	125
126	50.299	5.101	1981.521	0.5812	5762.12	18470.61	0.01388	6.864	126
127	51.621	5.261	1943.665	0.5790	5672.89	18113.61	0.01391	6.958	127
128	52.948	5.424	1907.066	0.5768	5586.86	17768.76	0.01394	7.052	128
129	54.279	5.590	1872.447	0.5747	5506.06	17442.64	0.01397	7.146	129
130	55.615	5.758	1840.469	0.5725	5432.33	17140.82	0.01400	7.240	130
131	56.955	5.930	1811.543	0.5704	5367.32	16868.26	0.01403	7.334	131
132	58.302	6.104	1786.563	0.5682	5313.46	16632.11	0.01406	7.428	132
133	59.653	6.282	1765.551	0.5660	5271.04	16432.56	0.01409	7.522	133
134	61.011	6.462	1748.980	0.5639	5241.59	16274.99	0.01412	7.617	134
135	62.376	6.645	1736.757	0.5617	5225.26	16158.22	0.01416	7.711	135
136	63.750	6.8	1729.141	0.5595	5222.49	16083.38	0.01419	7.805	136
137	65.132	7.024	1725.497	0.5573	5231.93	16045.82	0.01422	7.900	137
138	66.525	7.214	1725.845	0.5551	5253.68	16045.34	0.01425	7.996	138
139	67.928	7.416	1729.047	0.5529	5284.44	16071.31	0.01428	8.091	139
140	69.343	7.617	1734.200	0.5507	5321.53	16115.34	0.01431	8.187	140
141	70.771	7.825	1740.890	0.5485	5363.79	16173.56	0.01434	8.284	141
142	72.211	8.036	1748.707	0.5462	5403.81	16223.57	0.01437	8.381	142
143	73.662	8.251	1756.606	0.5440	5438.32	16255.71	0.01440	8.478	143
144	75.122	8.470	1760.418	0.5417	5460.44	16249.79	0.01443	8.576	144
145	76.589	8.693	1744.453	0.5395	5464.69	16190.21	0.01446	8.674	145
146	78.060	8.919	1722.177	0.5372	5442.81	16053.51	0.01449	8.772	146
147	79.526	9.146	1705.932	0.5349	5387.87	15820.67	0.01453	8.869	147
148	80.982	9.374	1668.457	0.5327	5292.93	15473.66	0.01456	8.965	148
149	82.416	9.601	85.265	0.5327	212.87	800.66	0.01459	8.967	149
150	83.814	9.821	14.379	0.5327	48.37	181.93	0.01462	8.967	150
151	85.160	10.034	-4.818	0.5327	-154.30	-580.35	0.01465	8.967	151


GRAPH OF TORQUE VS POSITION
2316.73999
1828.87109
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365.26440
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31.24741
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67.18875
85.15942
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22.26207
40.23274
58.20341
76.17409
X-INCREMENT= 0.498539E+00
X-SCALE IS 0.498539E+01 PER INCH
Y-INCREMENT= 0.487869E+02
Y-SCALE IS 0.292721E+03 PER INCH

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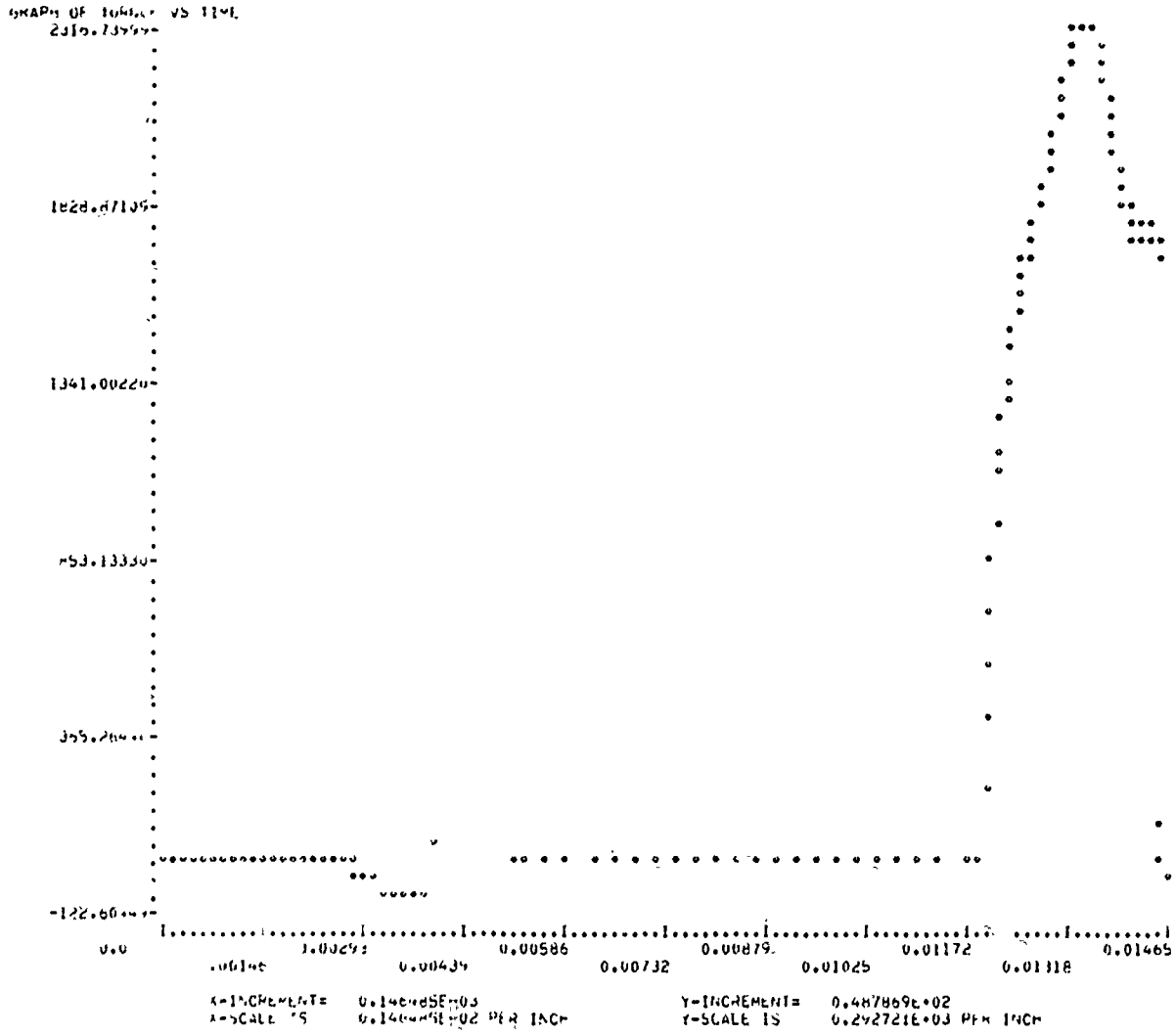

BARREL 3, 3 DEGREE INITIAL ANGLE, 8.967 EXIT, Y=.00066696*X**2.0, X=2.0 BARREL

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permit fully legible reproduction

BARREL J= 3 DEGREE INITIAL ANGLE= 0.767 EXIT, Y=.0006696*X**2.0, N=2.0 BARREL

J	POSITION (INCHES)	Y (INCHES)	TORQUE (IN-LBS)	SHEAR AREA (INCHES**2)	SHEAR STRESS (PSI)	BEARING STRESS (PSI)	TIME (SECONDS)	RIFLING ANGLE (DEGREES)	J
1	-4.492	0.0	0.0	**********	0.0	0.0	0.0	0.0	1
2	-4.494	0.0	0.0	**********	0.0	0.0	0.00010	0.0	2
3	-4.496	0.0	0.0	**********	0.0	0.0	0.00020	0.0	3
4	-4.498	0.0	0.0	**********	0.0	0.0	0.00030	0.0	4
5	-4.500	0.0	0.0	**********	0.0	0.0	0.00040	0.0	5
6	-4.502	0.0	0.0	**********	0.0	0.0	0.00050	0.0	6
7	-4.504	0.0	0.0	**********	0.0	0.0	0.00060	0.0	7
8	-4.506	0.0	0.0	**********	0.0	0.0	0.00070	0.0	8
9	-4.507	0.0	0.0	**********	0.0	0.0	0.00080	0.0	9
10	-3.909	0.	0.0	**********	0.0	0.0	0.00090	0.0	10
11	-3.695	0.0	0.0	**********	0.0	0.0	0.00100	0.0	11
12	-3.482	0.0	0.0	**********	0.0	0.0	0.00110	0.0	12
13	-3.268	0.0	0.0	**********	0.0	0.0	0.00120	0.0	13
14	-2.937	0.0	0.0	**********	0.0	0.0	0.00130	0.0	14
15	-2.651	0.0	0.0	**********	0.0	0.0	0.00140	0.0	15
16	-2.354	0.	0.0	**********	0.0	0.0	0.00150	0.0	16
17	-2.040	0.0	0.0	**********	0.0	0.0	0.00160	0.0	17
18	-1.736	0.0	0.0	**********	0.0	0.0	0.00170	0.0	18
19	-1.419	0.0	0.0	**********	0.0	0.0	0.00180	0.0	19
20	-1.094	0.0	0.0	**********	0.0	0.0	0.00190	0.0	20
21	-0.777	0.0	0.0	**********	0.0	0.0	0.00200	0.0	21
22	-0.455	0.0	0.0	**********	0.0	0.0	0.00210	0.0	22
23	-0.134	0.0	0.0	**********	0.0	0.0	0.00220	0.0	23
24	0.189	0.0	0.0	**********	0.0	0.0	0.00230	0.0	24
25	0.503	0.0	0.0	**********	0.0	0.0	0.00240	0.0	25
26	0.817	0.0	0.0	**********	0.0	0.0	0.00250	0.0	26
27	1.124	1.044	-11.144	0.0690	-28.15	-104.49	0.00260	3.009	27
28	1.425	1.093	-17.352	0.0685	-43.86	-162.68	0.00270	3.032	28
29	1.719	1.081	-25.029	0.0680	-63.32	-234.65	0.00280	3.054	29
30	2.002	1.095	-34.270	0.0675	-86.77	-321.34	0.00290	3.075	30
31	2.271	1.110	-45.050	0.0671	-114.23	-422.70	0.00300	3.096	31
32	2.525	1.124	-57.251	0.0667	-145.13	-536.71	0.00310	3.115	32
33	2.759	1.137	-70.395	0.0663	-178.47	-659.62	0.00320	3.132	33
34	2.970	1.148	-83.772	0.0659	-212.65	-785.48	0.00330	3.148	34
35	3.154	1.159	-96.755	0.0656	-245.61	-906.80	0.00340	3.162	35
36	3.310	1.167	-108.109	0.0653	-274.60	-1013.41	0.00350	3.174	36
37	3.433	1.174	-115.777	0.0651	-296.71	-1094.65	0.00360	3.183	37
38	3.523	1.179	-121.446	0.0649	-309.64	-1138.41	0.00370	3.190	38
39	3.579	1.182	-120.852	0.0649	-307.17	-1132.82	0.00380	3.194	39
40	3.602	1.183	-113.909	0.0648	-289.54	-1067.73	0.00390	3.196	40
41	3.599	1.183	25.841	0.0648	65.68	242.22	0.00400	3.195	41
42	3.600	1.194	0.0	0.0645	0.0	0.0	0.00515	3.211	42
43	3.600	1.194	0.0	0.0645	0.0	0.0	0.00540	3.211	43
44	3.600	1.194	0.0	0.0645	0.0	0.0	0.00570	3.211	44
45	3.600	1.194	0.0	0.0645	0.0	0.0	0.00600	3.211	45
46	3.600	1.194	0.0	0.0645	0.0	0.0	0.00630	3.211	46
47	3.600	1.194	0.0	0.0645	0.0	0.0	0.00660	3.211	47
48	3.600	1.194	0.0	0.0645	0.0	0.0	0.00690	3.211	48
49	3.600	1.194	0.0	0.0645	0.0	0.0	0.00720	3.211	49
50	3.600	1.194	0.0	0.0645	0.0	0.0	0.00750	3.211	50
51	3.600	1.194	0.0	0.0645	0.0	0.0	0.00780	3.211	51
52	3.600	1.194	0.0	0.0645	0.0	0.0	0.00810	3.211	52

53	3.800	1.194	0.0	0.0645	0.0	0.0	0.00840	3.211	53
54	3.800	1.194	0.0	0.0645	0.0	0.0	0.00870	3.211	54
55	3.800	1.194	0.0	0.0645	0.0	0.0	0.00900	3.211	55
56	3.800	1.194	0.0	0.0645	0.0	0.0	0.00930	3.211	56
57	3.800	1.194	0.0	0.0645	0.0	0.0	0.00960	3.211	57
58	3.800	1.194	0.0	0.0645	0.0	0.0	0.00990	3.211	58
59	3.800	1.194	0.0	0.0645	0.0	0.0	0.01020	3.211	59
60	3.800	1.194	0.0	0.0645	0.0	0.0	0.01050	3.211	60
61	3.800	1.194	0.0	0.0645	0.0	0.0	0.01080	3.211	61
62	3.800	1.194	0.0	0.0645	0.0	0.0	0.01110	3.211	62
63	3.800	1.194	0.0	0.0645	0.0	0.0	0.01140	3.211	63
64	3.800	1.194	0.0	0.0645	0.0	0.0	0.01170	3.211	64
65	3.800	1.194	0.0	0.0645	0.0	0.0	0.01200	3.211	65
66	3.800	1.194	208.551	0.0645	530.39	1954.88	0.01205	3.211	66
67	3.961	1.204	390.5	0.0642	993.72	3661.04	0.01206	3.223	67
68	4.102	1.211	553.271	0.0640	1408.18	5186.03	0.01209	3.233	68
69	4.232	1.219	697.618	0.0637	1776.17	6538.99	0.01212	3.243	69
70	4.361	1.224	824.867	0.0635	2100.84	7731.66	0.01215	3.253	70
71	4.495	1.234	936.434	0.0633	2385.81	8777.32	0.01218	3.263	71
72	4.640	1.242	1033.861	0.0630	2634.92	9690.03	0.01222	3.274	72
73	4.803	1.251	1118.547	0.0628	2852.06	10484.05	0.01225	3.286	73
74	4.987	1.262	1192.044	0.0624	3041.03	11173.24	0.01228	3.300	74
75	5.195	1.274	1255.963	0.0621	3205.48	11770.93	0.01231	3.316	75
76	5.431	1.288	1311.244	0.0617	3348.82	12289.60	0.01234	3.333	76
77	5.696	1.303	1359.402	0.0612	3474.19	12740.69	0.01237	3.353	77
78	5.993	1.321	1401.475	0.0607	3584.45	13134.71	0.01240	3.376	78
79	6.321	1.340	1438.481	0.0602	3682.22	13481.19	0.01243	3.400	79
80	6.681	1.362	1471.320	0.0596	3769.80	13788.56	0.01246	3.427	80
81	7.075	1.385	1500.803	0.0589	3849.26	14064.43	0.01249	3.457	81
82	7.501	1.411	1527.648	0.0582	3922.44	14315.52	0.01252	3.489	82
83	7.956	1.439	1552.487	0.0574	3990.96	14547.74	0.01255	3.524	83
84	8.450	1.470	1575.877	0.0565	4056.26	14766.34	0.01259	3.560	84
85	8.972	1.502	1598.306	0.0556	4119.58	14975.86	0.01262	3.600	85
86	9.524	1.537	1620.201	0.0547	4182.03	15180.31	0.01265	3.641	86
87	10.107	1.574	1641.930	0.0537	4244.57	15383.15	0.01268	3.685	87
88	10.719	1.614	1663.802	0.0527	4307.99	15587.25	0.01271	3.731	88
89	11.359	1.655	1686.074	0.0516	4373.01	15795.13	0.01274	3.779	89
90	12.027	1.701	1709.5..	0.0504	4440.16	16008.70	0.01277	3.829	90
91	12.722	1.747	1732.971	0.0492	4509.94	16229.61	0.01280	3.881	91
92	13.443	1.797	1757.267	0.0480	4582.65	16458.94	0.01283	3.936	92
93	14.190	1.848	1782.842	0.0467	4658.51	16697.35	0.01286	3.992	93
94	14.962	1.903	1809.431	0.0454	4737.64	16945.16	0.01289	4.050	94
95	15.758	1.959	1837.021	0.0441	4820.02	17202.25	0.01292	4.109	95
96	16.578	2.017	1865.544	0.0427	4905.53	17468.00	0.01295	4.171	96
97	17.421	2.081	1894.999	0.0412	4993.91	17741.42	0.01299	4.234	97
98	18.286	2.145	1924.952	0.0397	5084.84	18021.27	0.01302	4.299	98
99	19.177	2.211	1955.511	0.0382	5177.86	18305.75	0.01305	4.366	99
100	20.090	2.284	1986.358	0.0367	5272.40	18592.80	0.01308	4.435	100
101	21.024	2.355	2017.234	0.0351	5367.80	18880.00	0.01311	4.505	101
102	21.980	2.432	2047.955	0.0334	5463.33	19164.70	0.01314	4.576	102
103	22.958	2.511	2077.919	0.0318	5558.18	19444.03	0.01317	4.650	103
104	23.954	2.593	2107.050	0.0301	5651.48	19714.88	0.01320	4.725	104
105	24.978	2.678	2134.367	0.0283	5742.18	19973.68	0.01323	4.801	105
106	26.020	2.766	2161.307	0.0265	5829.46	20217.58	0.01326	4.879	106
107	27.082	2.857	2185.655	0.0247	5912.25	20442.89	0.01329	4.959	107
108	28.165	2.952	2207.665	0.0229	5989.55	20646.39	0.01332	5.040	108
109	29.266	3.050	2227.062	0.0210	6060.43	20824.94	0.01336	5.122	109
110	30.388	3.151	2243.471	0.0191	6123.96	20975.61	0.01339	5.206	110
111	31.528	3.256	2256.510	0.0171	6179.25	21095.56	0.01342	5.292	111
112	32.685	3.364	2266.243	0.0152	6225.57	21182.62	0.01345	5.378	112

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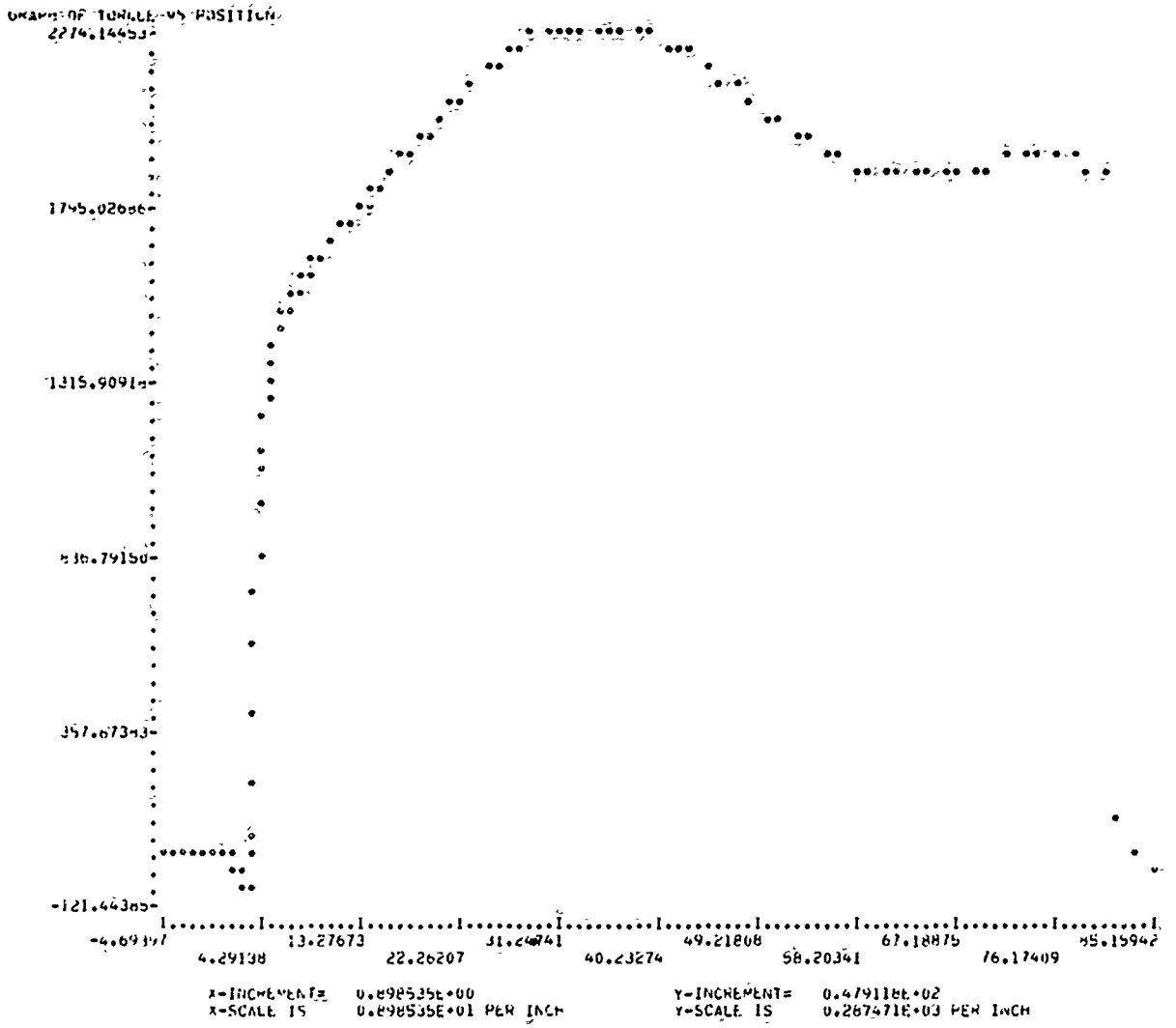
113	33.861	[illegible]	2272.169	0.6132	6262.10	21234.54 0.01348	5.466	113
114	35.052	[illegible]	2274.145	0.6111	6288.57	21250.20 0.01351	5.555	114
115	36.250	[illegible]	2272.221	0.6091	6304.52	21228.64 0.01354	5.646	115
116	37.481	[illegible]	2260.272	0.6070	6305.62	21170.00 0.01357	5.737	116
117	38.717	[illegible]	2256.345	0.6049	6303.89	21073.83 0.01360	5.829	117
118	39.906	[illegible]	2242.640	0.6027	6287.76	20942.32 0.01363	5.922	118
119	41.226	[illegible]	2225.267	0.6005	6261.49	20776.80 0.01366	6.017	119
120	42.447	[illegible]	2204.546	0.5984	6225.59	20579.43 0.01369	6.111	120
121	43.778	[illegible]	2180.882	0.5962	6181.20	20354.67 0.01372	6.207	121
122	45.084	[illegible]	2154.515	0.5940	6129.43	20105.63 0.01376	6.303	122
123	46.368	[illegible]	2126.221	0.5918	6071.42	19837.32 0.01379	6.400	123
124	47.671	[illegible]	2096.302	0.5896	6008.60	19554.42 0.01382	6.497	124
125	48.982	[illegible]	2065.559	0.5873	5943.04	19263.87 0.01385	6.595	125
126	50.295	[illegible]	2034.543	0.5851	5876.30	18970.83 0.01388	6.693	126
127	51.621	[illegible]	2003.907	0.5828	5810.23	18681.40 0.01391	6.791	127
128	52.945	[illegible]	1974.360	0.5806	5746.96	18402.37 0.01394	6.890	128
129	54.279	[illegible]	1946.624	0.5783	5686.47	18139.93 0.01397	6.989	129
130	55.615	[illegible]	1921.254	0.5760	5630.53	17899.60 0.01400	7.088	130
131	56.959	[illegible]	1898.761	0.5737	5582.81	17686.33 0.01403	7.188	131
132	58.302	[illegible]	1879.977	0.5714	5559.69	17507.30 0.01406	7.288	132
133	59.653	[illegible]	1864.227	0.5691	5537.54	17363.22 0.01409	7.388	133
134	61.011	[illegible]	1854.100	0.5668	5521.91	17258.46 0.01412	7.489	134
135	62.378	[illegible]	1847.527	0.5645	5531.05	17193.25 0.01416	7.590	135
136	63.750	[illegible]	1845.317	0.5621	5547.48	17168.59 0.01419	7.692	136
137	65.132	[illegible]	1847.001	0.5598	5575.95	17180.09 0.01422	7.795	137
138	66.525	[illegible]	1852.691	0.5574	5616.71	17227.90 0.01425	7.899	138
139	67.928	[illegible]	1861.002	0.5550	5666.55	17301.64 0.01428	8.002	139
140	69.343	[illegible]	1871.321	0.5526	5722.91	17393.17 0.01431	8.106	140
141	70.771	[illegible]	1883.266	0.5501	5784.74	17498.92 0.01434	8.212	141
142	72.211	[illegible]	1896.220	0.5477	5844.69	17596.52 0.01437	8.318	142
143	73.666	[illegible]	1909.336	0.5452	5899.49	17676.33 0.01440	8.426	143
144	75.122	[illegible]	1920.369	0.5427	5942.26	17718.10 0.01443	8.533	144
145	76.589	[illegible]	1927.413	0.5402	5967.45	17706.03 0.01446	8.642	145
146	78.060	[illegible]	1928.416	0.5377	5966.59	17616.12 0.01449	8.750	146
147	79.526	[illegible]	1924.342	0.5352	5932.51	17428.85 0.01453	8.858	147
148	80.982	[illegible]	1916.603	0.5327	5857.91	17124.75 0.01456	8.965	148
149	82.411	[illegible]	85.285	0.5327	212.87	800.66 0.01459	8.967	149
150	83.814	[illegible]	19.379	0.5327	48.37	181.93 0.01462	8.967	150
151	85.190	[illegible]	-61.818	0.5327	-154.30	-580.35 0.01465	8.967	151


GRAPH OF TORQUE VS POSITION
2274.14453
1795.02686
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-121.44385
-4.69197
4.29138
13.27673
22.26207
31.24741
40.23274
49.21808
58.20341
67.18875
76.17409
85.15942
X-INCREMENT= 0.898535E+00
X-SCALE IS 0.898535E+01 PER INCH
Y-INCREMENT= 0.479118E+02
Y-SCALE IS 0.267471E+03 PER INCH

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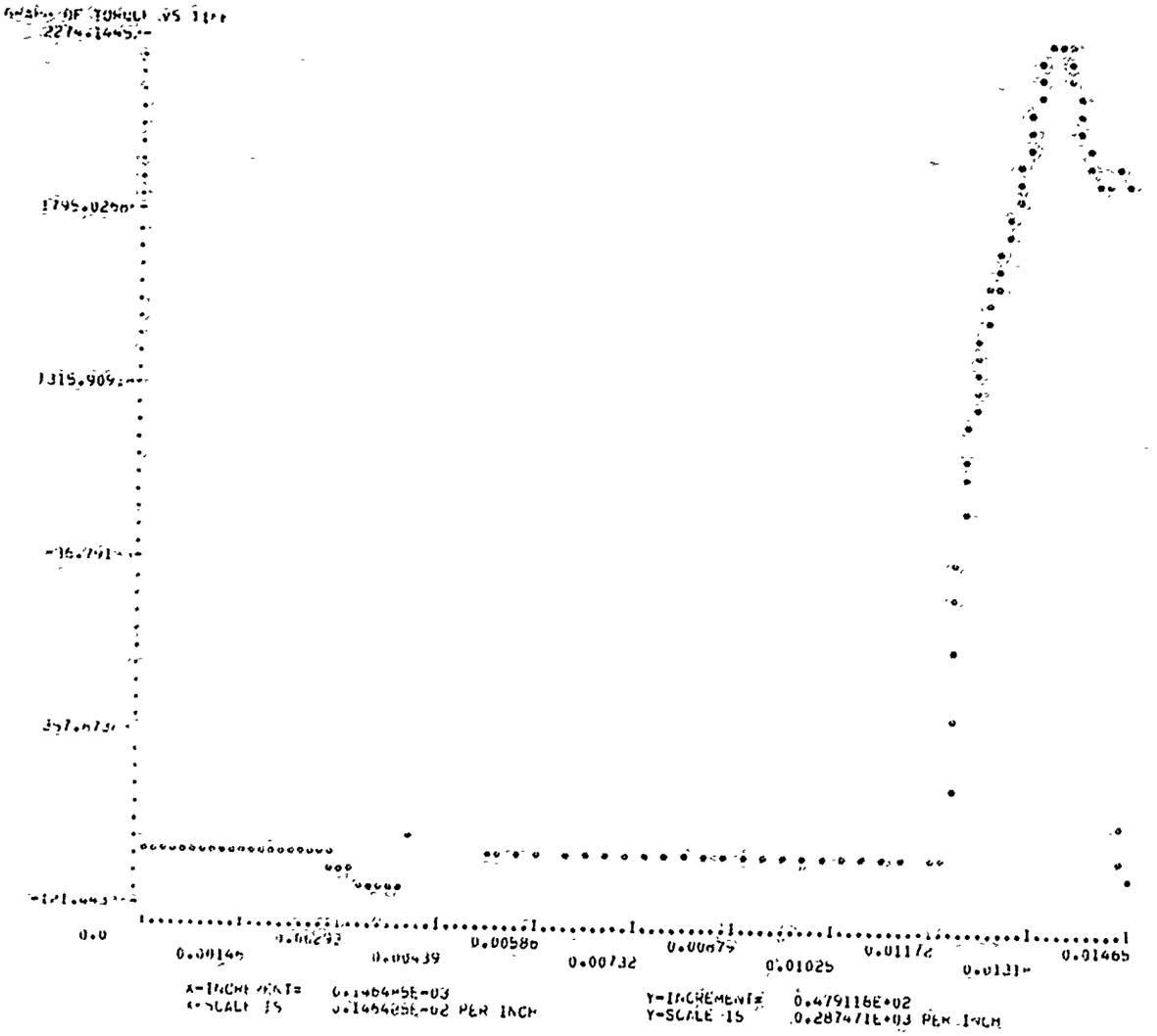

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PRESENT RIA AND 30 BARREL, 11IN FREE RUN, 11.75IN CONSTANT EXIT AT 8.967 DEGREES, RIA BARREL

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PRESENT MIA AND JG BARRELS. IFS FREE MOVE 11.751N CONSTANT EXIT AT 8.967 DEGREES. MIA BARREL

J	POSITION (INCHES)	Y (INCHES)	TORQUE (IN-LBS)	SHEAR AREA (INCHES**2)	SHEAR STRESS (PSI)	BEARING STRESS (PSI)	TIME (SECONDS)	RIFLING ANGLE (DEGREES)	J
1	-4.692	0.0	0.0	**********	0.0	0.0	0.0	0.0	1
2	-4.684	0.0	0.0	**********	0.0	0.0	0.00010	0.0	2
3	-4.679	0.0	0.0	**********	0.0	0.0	0.00020	0.0	3
4	-4.665	0.0	0.0	**********	0.0	0.0	0.00030	0.0	4
5	-4.567	0.0	0.0	**********	0.0	0.0	0.00040	0.0	5
6	-4.505	0.0	0.0	**********	0.0	0.0	0.00050	0.0	6
7	-4.396	0.0	0.0	**********	0.0	0.0	0.00060	0.0	7
8	-4.264	0.0	0.0	**********	0.0	0.0	0.00070	0.0	8
9	-4.097	0.0	0.0	**********	0.0	0.0	0.00080	0.0	9
10	-3.906	0.0	0.0	**********	0.0	0.0	0.00090	0.0	10
11	-3.696	0.0	0.0	**********	0.0	0.0	0.00100	0.0	11
12	-3.462	0.0	0.0	**********	0.0	0.0	0.00110	0.0	12
13	-3.206	0.0	0.0	**********	0.0	0.0	0.00120	0.0	13
14	-2.937	0.0	0.0	**********	0.0	0.0	0.00130	0.0	14
15	-2.651	0.0	0.0	**********	0.0	0.0	0.00140	0.0	15
16	-2.354	0.0	0.0	**********	0.0	0.0	0.00150	0.0	16
17	-2.049	0.0	0.0	**********	0.0	0.0	0.00160	0.0	17
18	-1.736	0.0	0.0	**********	0.0	0.0	0.00170	0.0	18
19	-1.419	0.0	0.0	**********	0.0	0.0	0.00180	0.0	19
20	-1.098	0.0	0.0	**********	0.0	0.0	0.00190	0.0	20
21	-0.777	0.0	0.0	**********	0.0	0.0	0.00200	0.0	21
22	-0.455	0.0	0.0	**********	0.0	0.0	0.00210	0.0	22
23	-0.134	0.0	0.0	**********	0.0	0.0	0.00220	0.0	23
24	0.186	0.0	0.0	**********	0.0	0.0	0.00230	0.0	24
25	0.503	0.0	0.0	**********	0.0	0.0	0.00240	0.0	25
26	0.816	0.0	0.0	**********	0.0	0.0	0.00250	0.0	26
27	1.124	0.0	0.0	0.6684	0.0	0.0	0.00260	0.0	27
28	1.425	0.0	0.0	0.6688	0.0	0.0	0.00270	0.0	28
29	1.719	0.0	0.0	0.6688	0.0	0.0	0.00280	0.0	29
30	2.002	0.0	0.0	0.6688	0.0	0.0	0.00290	0.0	30
31	2.271	0.0	0.0	0.6688	0.0	0.0	0.00300	0.0	31
32	2.525	0.0	0.0	0.6688	0.0	0.0	0.00310	0.0	32
33	2.759	0.0	0.0	0.6688	0.0	0.0	0.00320	0.0	33
34	2.970	0.0	0.0	0.6688	0.0	0.0	0.00330	0.0	34
35	3.154	0.0	0.0	0.6688	0	0.0	0.00340	0.0	35
36	3.310	0.0	0.0	0.6688	.0	0.0	0.00350	0.0	36
37	3.433	0.0	0.0	0.6688	0.0	0.0	0.00360	0.0	37
38	3.522	0.0	0.0	0.6688	0.0	0.0	0.00370	0.0	38
39	3.574	0.0	0.0	0.6688	0.0	0.0	0.00380	0.0	39
40	3.602	0.0	0.0	0.6688	0.0	0.0	0.00390	0.0	40
41	3.595	0.0	0.0	0.6688	0.0	0.0	0.00400	0.0	41
42	3.800	0.0	0.0	0.6688	0.0	0.0	0.00515	0.0	42
43	3.800	0.0	0.0	0.6688	0.0	0.0	0.00540	0.0	43
44	3.800	0.0	0.0	0.6688	0.0	0.0	0.00570	0.0	44
45	3.800	0.0	0.0	0.6688	0.0	0.0	0.00600	0.0	45
46	3.800	0.0	0.0	0.6688	0.0	0.0	0.00630	0.0	46
47	3.800	0.0	0.0	0.6688	0.0	0.0	0.00660	0.0	47
48	3.800	0.0	.0	0.6688	0.0	0.0	0.00690	0.0	48
49	3.800	0.0	.0	0.6688	0.0	0.0	0.00720	0.0	49
50	3.800	0.0	0.0	0.6688	0.0	0.0	0.00750	0.0	50
51	3.800	0.0	0.0	0.6688	0.0	0.0	0.00780	0.0	51
52	3.800	0.0	0.0	0.6688	0.0	0.0	0.00810	0.0	52

53	3.800	0.0	0.0	0.6688	0.0	0.0	0.00840	0.0	53
54	3.800	0.0	0.0	0.6688	0.0	0.0	0.00870	0.0	54
55	3.800	0.0	0.0	0.6688	0.0	0.0	0.00900	0.0	55
56	3.800	0.0	0.0	0.6688	0.0	0.0	0.00930	0.0	56
57	3.800	0.0	0.0	0.6688	0.0	0.0	0.00960	0.0	57
58	3.800	0.0	0.0	0.6688	0.0	0.0	0.00990	0.0	58
59	3.800	0.0	0.0	0.6688	0.0	0.0	0.01020	0.0	59
60	3.800	0.0	0.0	0.6688	0.0	0.0	0.01050	0.0	60
61	3.800	0.0	0.0	0.6688	0.0	0.0	0.01080	0.0	61
62	3.800	0.0	0.0	0.6688	0.0	0.0	0.01110	0.0	62
63	3.800	0.0	0.0	0.6688	0.0	0.0	0.01140	0.0	63
64	3.800	0.0	0.0	0.6688	0.0	0.0	0.01180	0.0	64
65	3.800	0.0	0.0	0.6688	0.0	0.0	0.01200	0.0	65
66	3.800	0.0	0.0	0.6688	0.0	0.0	0.01203	0.0	66
67	3.961	0.0	0.0	0.6688	0.0	0.0	0.01206	0.0	67
68	4.102	-0.000	4.430	0.6688	11.21	54.79	0.01209	0.021	68
69	4.232	-0.000	12.024	0.6683	30.41	148.53	0.01212	0.043	69
70	4.361	0.000	22.935	0.6678	58.04	283.31	0.01215	0.065	70
71	4.495	0.000	37.808	0.6673	95.75	467.05	0.01218	0.088	71
72	4.640	0.001	57.358	0.6667	145.39	708.54	0.01222	0.113	72
73	4.803	0.001	82.256	0.6661	208.69	1016.12	0.01225	0.141	73
74	4.987	0.001	113.064	0.6654	287.16	1396.69	0.01228	0.172	74
75	5.195	0.002	150.181	0.6646	381.89	1855.19	0.01231	0.208	75
76	5.431	0.003	193.[illegible]	0.6637	493.54	2394.30	0.01234	0.248	76
77	5.696	0.004	244.0[illegible]	0.6626	622.33	3014.44	0.01237	0.292	77
78	5.993	0.005	300.649	0.6615	768.04	3713.88	0.01240	0.342	78
79	6.321	0.006	363.405	0.6603	930.12	4489.06	0.01243	0.398	79
80	6.681	0.011	431.878	0.6589	1107.67	5334.86	0.01246	0.458	80
81	7.075	0.014	505.564	0.6574	1299.59	6245.02	0.01249	0.524	81
82	7.501	0.018	583.854	0.6558	1504.62	7212.50	0.01252	0.595	82
83	7.959	0.023	666.263	0.6541	1721.40	8229.85	0.01255	0.671	83
84	8.450	0.029	752.062	0.6522	1948.54	9289.50	0.01259	0.752	84
85	8.972	0.037	840.694	0.6503	2184.69	10384.07	0.01262	0.838	85
86	9.524	0.045	931.591	0.6482	2428.55	11506.52	0.01265	0.929	86
87	10.107	0.055	1024.230	0.6461	2678.94	12650.39	0.01268	1.024	87
88	10.719	0.067	1118.137	0.6438	2934.76	13809.80	0.01271	1.123	88
89	11.359	0.080	1212.895	0.6415	3195.07	14979.58	0.01274	1.226	89
90	12.027	0.095	1308.133	0.6391	3459.03	16155.12	0.01277	1.333	90
91	12.722	0.111	1403.540	0.6366	3725.94	17332.56	0.01280	1.444	91
92	13.443	0.130	1498.845	0.6340	3995.18	18508.54	0.01283	1.559	92
93	14.190	0.151	1593.810	0.6313	4266.21	19680.07	0.01286	1.678	93
94	14.962	0.175	1688.227	0.6286	4538.59	20844.58	0.01289	1.797	94
95	15.758	0.201	1781.912	0.6258	4811.89	21994.77	0.01292	1.921	95
96	16.578	0.229	1874.671	0.6229	5085.66	23143.22	0.01295	2.047	96
97	17.421	0.260	1966.319	0.6200	5359.46	24272.61	0.01299	2.176	97
98	18.288	0.294	2056.669	0.6170	5632.84	25385.62	0.01302	2.308	98
99	19.177	0.331	2145.457	0.6140	5905.21	26479.46	0.01305	2.442	99
100	20.090	0.371	2232.564	0.6109	6175.97	27551.15	0.01308	2.579	100
101	21.024	0.414	2317.559	0.6077	6444.36	28597.34	0.01311	2.717	101
102	21.980	0.461	2400.300	0.6046	6709.55	29614.25	0.01314	2.858	102
103	22.956	0.511	2480.346	0.6013	6970.63	30597.94	0.01317	3.001	103
104	23.954	0.565	2557.371	0.5980	7226.52	31543.84	0.01320	3.145	104
105	24.978	0.622	2630.948	0.5947	7475.94	32446.71	0.01323	3.292	105
106	26.020	0.683	2700.719	0.5914	7717.79	33302.12	0.01326	3.440	106
107	27.082	0.748	2766.217	0.5880	7950.61	34104.32	0.01329	3.589	107
108	28.165	0.818	2827.011	0.5845	8172.98	34847.93	0.01332	3.740	108
109	29.266	0.891	2882.677	0.5811	8383.51	35527.83	0.01336	3.892	109
110	30.388	0.969	2932.802	0.5776	8580.75	36138.90	0.01339	4.046	110
111	31.528	1.051	2976.970	0.5741	8763.22	36676.04	0.01342	4.200	111
112	32.685	1.138	3014.849	0.5705	8929.64	37135.16	0.01345	4.355	112

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113	33.861	1.229	3046.056	0.5670	9078.64	37512.14	0.01348	4.511	113
114	35.092	1.262	3070.503	0.5634	9209.23	37804.43	0.01351	4.698	114
115	36.354	1.295	3087.967	0.5599	9320.58	38010.29	0.01354	4.825	115
116	37.648	1.329	3098.264	0.5563	9411.84	38128.06	0.01357	4.902	116
117	38.977	1.364	3101.403	0.5527	9482.56	38157.92	0.01360	5.139	117
118	39.966	1.751	3097.675	0.5491	9532.96	38102.54	0.01363	5.296	118
119	41.224	1.472	3087.187	0.5455	9563.02	37963.74	0.01366	5.453	119
120	42.697	1.995	3070.217	0.5420	9573.14	37745.08	0.01369	5.609	120
121	43.778	2.122	3047.339	0.5384	9564.68	37453.65	0.01372	5.765	121
122	45.068	2.254	3018.966	0.5349	9538.57	37094.91	0.01376	5.920	122
123	46.389	2.391	2985.834	0.5313	9496.58	36677.20	0.01379	6.075	123
124	47.671	2.531	2948.562	0.5278	9440.48	36206.82	0.01382	6.229	124
125	48.982	2.676	2908.105	0.5243	9373.04	35701.53	0.01385	6.381	125
126	50.299	2.825	2865.267	0.5208	9296.45	35164.59	0.01388	6.533	126
127	51.621	2.978	2820.809	0.5174	9213.38	34608.92	0.01391	6.683	127
128	52.948	3.136	2775.823	0.5140	9126.95	34046.57	0.01394	6.833	128
129	54.279	3.297	2731.211	0.5106	9040.10	33488.77	0.01397	6.981	129
130	55.615	3.462	2687.782	0.5072	8955.66	32945.79	0.01400	7.128	130
131	56.955	3.632	2646.323	0.5038	8876.27	32427.15	0.01403	7.275	131
132	58.302	3.805	2607.470	0.5005	8805.59	31945.54	0.01406	7.420	132
133	59.653	3.983	2572.685	0.4972	8744.72	31504.09	0.01409	7.564	133
134	61.011	4.165	2541.463	0.4939	8696.28	31111.35	0.01412	7.707	134
135	62.377	4.351	2514.408	0.4906	8661.23	30769.68	0.01416	7.849	135
136	63.751	4.543	2491.779	0.4873	8640.66	30482.29	0.01419	7.991	136
137	65.136	4.739	2473.266	0.4841	8634.15	30244.53	0.01422	8.132	137
138	66.525	4.939	2458.840	0.4808	8641.99	30058.20	0.01425	8.273	138
139	67.924	5.145	2447.558	0.4776	8660.73	29909.54	0.01428	8.413	139
140	69.343	5.358	2438.508	0.4743	8687.56	29788.10	0.01431	8.553	140
141	70.771	5.574	2431.347	0.4711	8721.48	29689.65	0.01434	8.693	141
142	72.211	5.794	2423.492	0.4679	8753.29	29582.65	0.01437	8.832	142
143	73.662	6.021	230.613	0.4679	582.31	2138.62	0.01440	8.967	143
144	75.122	6.252	227.447	0.4679	574.32	2109.25	0.01443	8.967	144
145	76.589	6.489	218.415	0.4679	551.51	2025.49	0.01446	8.967	145
146	78.060	6.729	201.367	0.4679	508.46	1867.40	0.01449	8.967	146
147	79.529	6.967	174.552	0.4679	440.86	1619.10	0.01453	8.967	147
148	80.982	7.199	136.557	0.4679	344.81	1266.38	0.01456	8.967	148
149	82.416	7.423	85.285	0.4679	215.35	790.90	0.01459	8.967	149
150	83.814	7.631	19.379	0.4679	48.93	179.71	0.01462	8.967	150
151	85.168	7.819	-61.819	0.4679	-156.10	-573.28	0.01465	8.967	151

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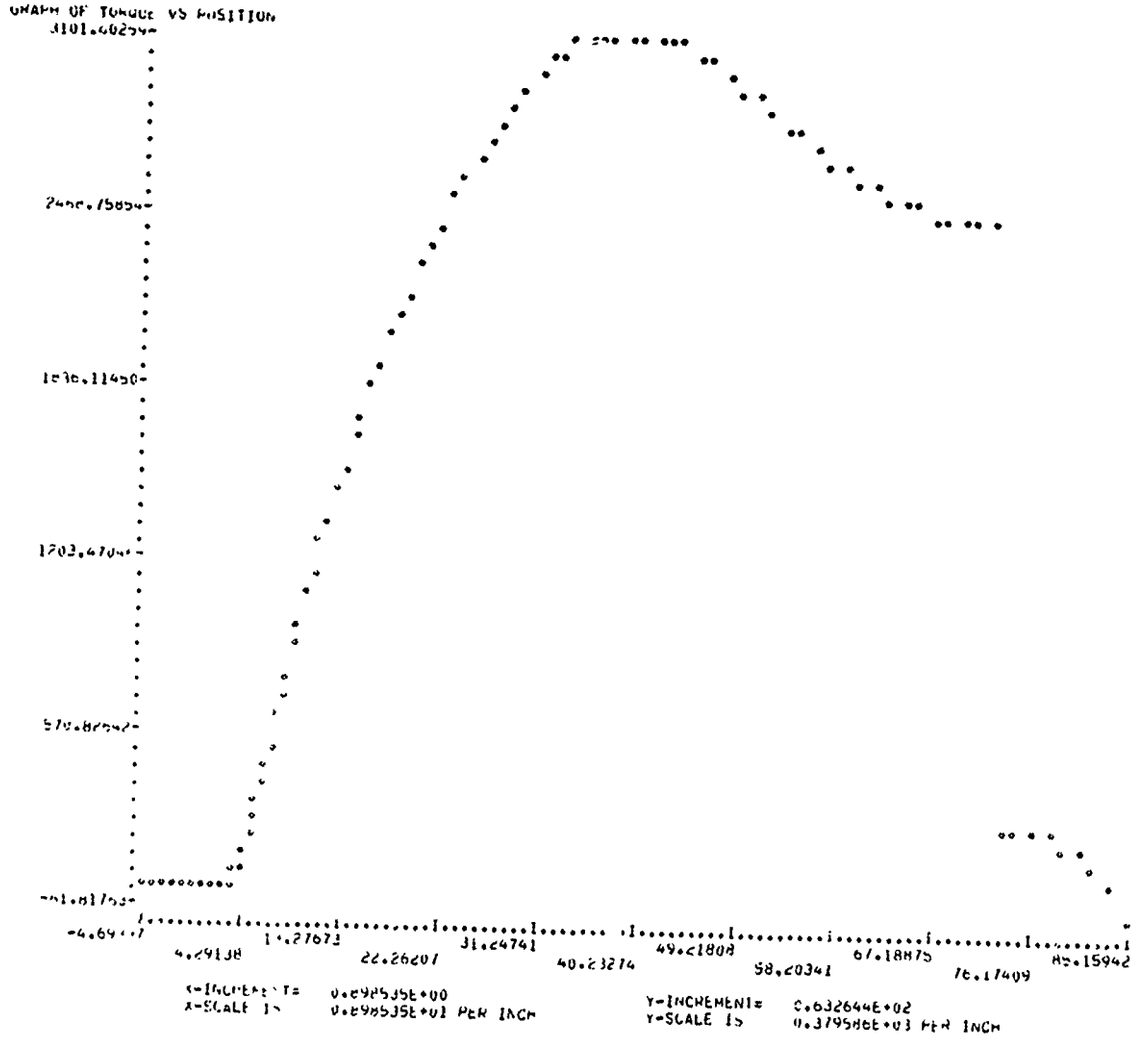
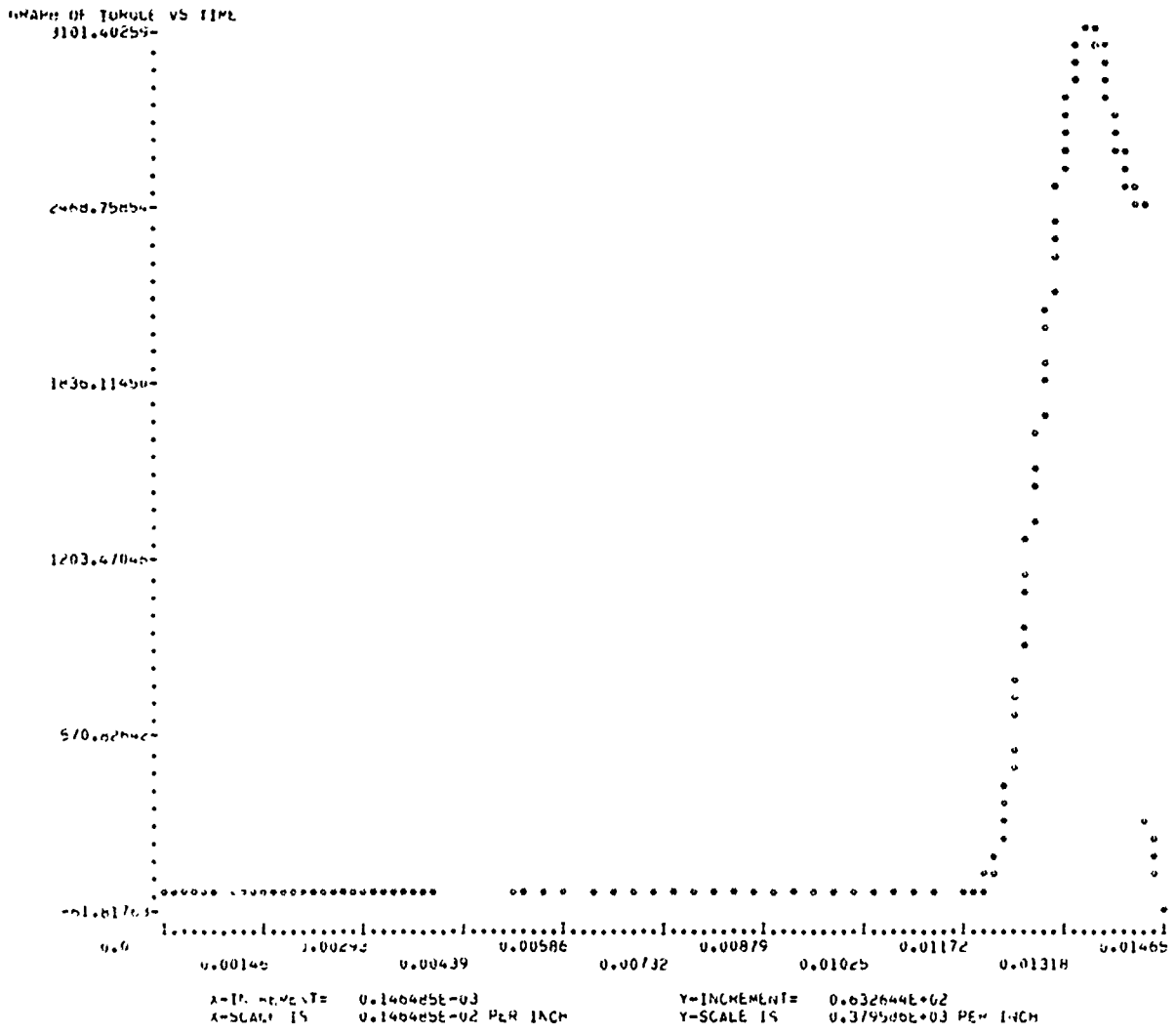



SHAPE OF TORQUE VS TIME
3101.40259
2468.75858
1836.11458
1203.47058
570.82658
-61.817
0.0
0.00146
0.00293
0.00439
0.00586
0.00732
0.00879
0.01026
0.01172
0.01318
0.01465
X-INCREMENT= 0.1464858-03
X-SCALE IS 0.1464858-02 PER INCH
Y-INCREMENT= 0.632644E+02
Y-SCALE IS 0.3795868+03 PER INCH

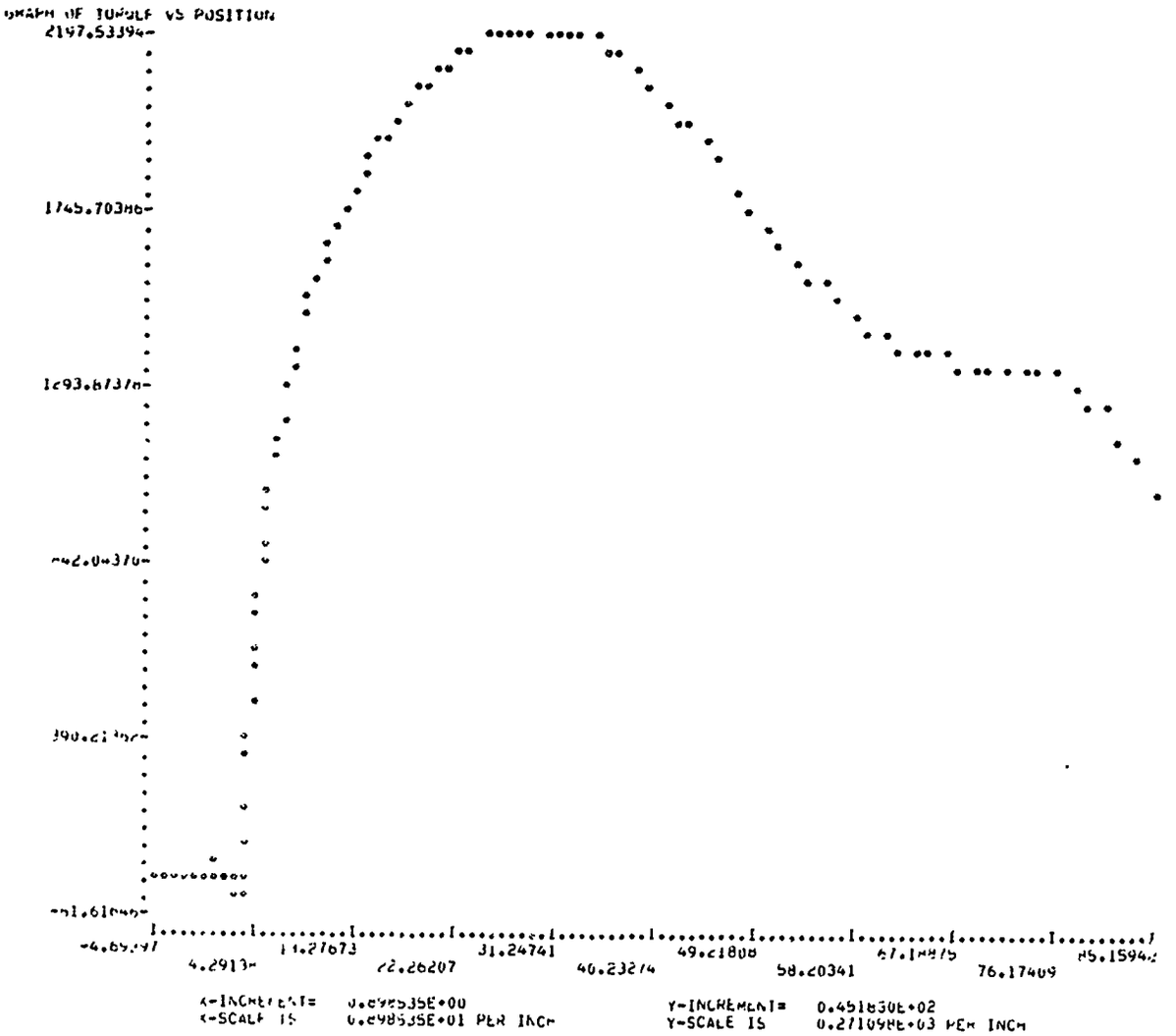
PRESENT HERCULES BARREL WITH V. INITIAL ANGLE+8.9667 EXIT AND Y=.01008*X**1.5

PRESENT HERCULES BARREL WITH U. INITIAL ANGLE=0.9667 EXIT AND Y=.01008*X**1.5

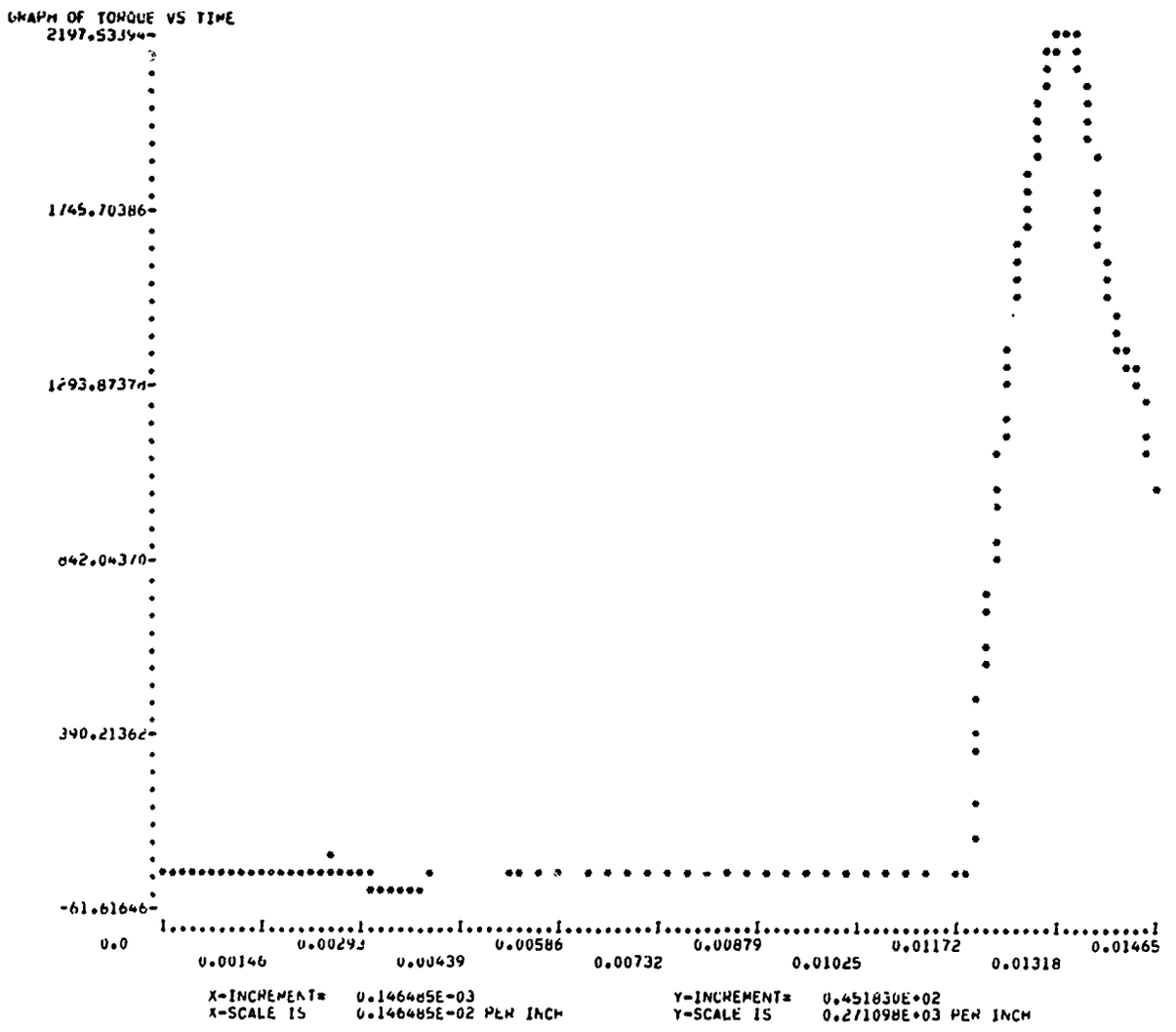
J	POSITION (INCHES)	Y (INCHES)	TORQUE (IN-LBS)	SHEAR AREA (INCHES**2)	SHEAR STRESS (PSI)	BEARING STRESS (PSI)	TIME (SECONDS)	RIFLING ANGLE (DEGREES)	J
1	-4.692	0.0	0.0	**********	0.0	0.0	0.0	0.0	1
2	-4.684	0.0	0.0	**********	0.0	0.0	0.00010	0.0	2
3	-4.679	0.0	0.0	**********	0.0	0.0	0.00020	0.0	3
4	-4.645	0.0	0.0	**********	0.0	0.0	0.00030	0.0	4
5	-4.587	0.0	0.0	**********	0.0	0.0	0.00040	0.0	5
6	-4.505	0.0	0.0	**********	0.0	0.0	0.00050	0.0	6
7	-4.396	0.0	0.0	**********	0.0	0.0	0.00060	0.0	7
8	-4.260	0.0	0.0	**********	0.0	0.0	0.00070	0.0	8
9	-4.097	0.0	0.0	**********	0.0	0.0	0.00080	0.0	9
10	-3.909	0.0	0.0	**********	0.0	0.0	0.00090	0.0	10
11	-3.696	0.0	0.0	**********	0.0	0.0	0.00100	0.0	11
12	-3.462	0.0	0.0	**********	0.0	0.0	0.00110	0.0	12
13	-3.208	0.0	0.0	**********	0.0	0.0	0.00120	0.0	13
14	-2.937	0.0	0.0	**********	0.0	0.0	0.00130	0.0	14
15	-2.651	0.0	0.0	**********	0.0	0.0	0.00140	0.0	15
16	-2.354	0.0	0.0	**********	0.0	0.0	0.00150	0.0	16
17	-2.049	0.0	0.0	**********	0.0	0.0	0.00160	0.0	17
18	-1.736	0.0	0.0	**********	0.0	0.0	0.00170	0.0	18
19	-1.419	0.0	0.0	**********	0.0	0.0	0.00180	0.0	19
20	-1.098	0.0	0.0	**********	0.0	0.0	0.00190	0.0	20
21	-0.777	0.0	0.0	**********	0.0	0.0	0.00200	0.0	21
22	-0.455	0.0	0.0	**********	0.0	0.0	0.00210	0.0	22
23	-0.134	0.0	0.0	**********	0.0	0.0	0.00220	0.0	23
24	0.186	0.0	0.0	**********	0.0	0.0	0.00230	0.0	24
25	0.503	0.0	0.0	**********	0.0	0.0	0.00240	0.0	25
26	0.816	0.0	0.0	**********	0.0	0.0	0.00250	0.0	26
27	1.124	0.012	36.857	0.6485	96.15	455.74	0.00260	0.918	27
28	1.425	0.017	27.644	0.6459	72.34	341.45	0.00270	1.034	28
29	1.719	0.023	18.942	0.6436	49.74	233.95	0.00280	1.136	29
30	2.006	0.029	10.076	0.6415	26.54	124.45	0.00290	1.225	30
31	2.271	0.035	0.702	0.6397	1.85	8.66	0.00300	1.305	31
32	2.525	0.040	-9.257	0.6381	-24.52	-114.32	0.00310	1.376	32
33	2.759	0.046	-19.663	0.6367	-52.19	-242.83	0.00320	1.439	33
34	2.970	0.052	-30.169	0.6355	-80.23	-372.56	0.00330	1.493	34
35	3.154	0.058	-40.264	0.6345	-107.24	-497.20	0.00340	1.538	35
36	3.310	0.061	-49.236	0.6336	-131.32	-607.99	0.00350	1.576	36
37	3.433	0.064	-56.323	0.6329	-150.38	-695.49	0.00360	1.605	37
38	3.523	0.067	-60.701	0.6325	-162.19	-749.54	0.00370	1.626	38
39	3.579	0.068	-61.618	0.6322	-164.71	-760.86	0.00380	1.638	39
40	3.602	0.069	-58.528	0.6321	-156.48	-722.71	0.00390	1.644	40
41	3.595	0.069	13.269	0.6321	35.48	163.85	0.00400	1.642	41
42	3.800	0.075	0.0	0.6311	0.0	0.0	0.00515	1.688	42
43	3.800	0.075	0.0	0.6311	0.0	0.0	0.00540	1.688	43
44	3.800	0.075	0.0	0.6311	0.0	0.0	0.00570	1.688	44
45	3.80	0.075	0.0	0.6311	0.0	0.0	0.00600	1.688	45
46	3.800	0.075	0.0	0.6311	0.0	0.0	0.00630	1.688	46
47	3.800	0.075	0.0	0.6311	0.0	0.0	0.00660	1.688	47
48	3.800	0.075	0.0	0.6311	0.0	0.0	0.00690	1.688	48
49	3.800	0.075	0.0	0.6311	0.0	0.0	0.00720	1.688	49
50	3.800	0.075	0.0	0.6311	0.0	0.0	0.00750	1.688	50
51	3.800	0.075	0.0	0.6311	0.0	0.0	0.00780	1.688	51
52	3.800	0.075	0.0	0.6311	0.0	0.0	0.00810	1.688	52

53	3.800	0.075	0.0	0.6311	0.0	0.0	0.00840	1.688	53
54	3.800	0.075	0.0	0.6311	0.0	0.0	0.00870	1.688	54
55	3.800	0.075	0.0	0.6311	0.0	0.0	0.00900	1.688	55
56	3.800	0.075	0.0	0.6311	0.0	0.0	0.00930	1.688	56
57	3.800	0.075	0.0	0.6311	0.0	0.0	0.00960	1.688	57
58	3.800	0.075	0.0	0.6311	0.0	0.0	0.00990	1.688	58
59	3.800	0.075	0.0	0.6311	0.0	0.0	0.01020	1.688	59
60	3.800	0.075	0.0	0.6311	0.0	0.0	0.01050	1.688	60
61	3.800	0.075	0.0	0.6311	0.0	0.0	0.01080	1.688	61
62	3.800	0.075	0.0	0.6311	0.0	0.0	0.01110	1.688	62
63	3.800	0.075	0.0	0.6311	0.0	0.0	0.01140	1.688	63
64	3.800	0.075	0.0	0.6311	0.0	0.0	0.01180	1.688	64
65	3.800	0.075	0.0	0.6311	0.0	0.0	0.01200	1.688	65
66	3.800	0.075	104.578	0.6311	293.44	1353.04	0.01203	1.688	66
67	3.961	0.079	208.867	0.6303	560.04	2576.99	0.01206	1.724	67
68	4.102	0.084	300.751	0.6296	807.28	3713.46	0.01209	1.754	68
69	4.232	0.088	385.634	0.6289	1036.16	4761.46	0.01212	1.782	69
70	4.361	0.092	464.482	0.6283	1249.22	5734.93	0.01215	1.808	70
71	4.495	0.096	538.530	0.6277	1449.81	6649.09	0.01218	1.836	71
72	4.640	0.101	609.057	0.6270	1641.44	7519.78	0.01222	1.865	72
73	4.803	0.106	677.240	0.6263	1827.32	8361.42	0.01225	1.898	73
74	4.987	0.112	744.030	0.6255	2010.15	9185.84	0.01228	1.934	74
75	5.195	0.119	810.124	0.6246	2191.89	10001.60	0.01231	1.974	75
76	5.431	0.129	875.941	0.6236	2373.77	10813.87	0.01234	2.018	76
77	5.696	0.137	941.644	0.6225	2556.36	11624.70	0.01237	2.067	77
78	5.993	0.148	1007.204	0.6213	2739.61	12433.58	0.01240	2.120	78
79	6.321	0.160	1072.418	0.6200	2923.09	13238.12	0.01243	2.177	79
80	6.681	0.174	1136.990	0.6186	3106.05	14034.70	0.01246	2.238	80
81	7.075	0.190	1200.602	0.6171	3287.62	14819.17	0.01249	2.303	81
82	7.501	0.207	1262.859	0.6156	3466.89	15587.35	0.01252	2.371	82
83	7.959	0.228	1323.581	0.6140	3643.04	16335.47	0.01255	2.443	83
84	8.450	0.248	1382.396	0.6123	3815.34	17060.36	0.01259	2.517	84
85	8.972	0.271	1439.142	0.6106	3983.24	17759.66	0.01262	2.593	85
86	9.524	0.294	1493.700	0.6088	4146.36	18431.84	0.01265	2.672	86
87	10.107	0.324	1546.025	0.6070	4304.47	19076.17	0.01268	2.752	87
88	10.719	0.354	1596.055	0.6051	4457.53	19692.61	0.01271	2.834	88
89	11.359	0.385	1643.967	0.6032	4605.59	20281.77	0.01274	2.917	89
90	12.027	0.426	1689.710	0.6013	4748.82	20844.52	0.01277	3.002	90
91	12.722	0.457	1733.433	0.5994	4887.43	21382.20	0.01280	3.087	91
92	13.443	0.497	1775.246	0.5974	5021.69	21896.16	0.01283	3.173	92
93	14.190	0.539	1815.252	0.5954	5151.83	22387.71	0.01286	3.260	93
94	14.962	0.583	1853.552	0.5935	5276.08	22858.05	0.01289	3.347	94
95	15.758	0.631	1890.229	0.5915	5400.64	23308.24	0.01292	3.435	95
96	16.578	0.680	1925.360	0.5895	5519.54	23738.73	0.01295	3.523	96
97	17.421	0.733	1958.043	0.5875	5634.81	24149.73	0.01299	3.611	97
98	18.288	0.788	1990.786	0.5855	5746.36	24541.12	0.01302	3.700	98
99	19.177	0.847	2021.060	0.5834	5853.94	24912.05	0.01305	3.788	99
100	20.090	0.908	2049.935	0.5814	5957.23	25261.39	0.01308	3.877	100
101	21.024	0.972	2076.310	0.5794	6055.80	25587.45	0.01311	3.966	101
102	21.980	1.039	2100.940	0.5774	6149.08	25888.15	0.01314	4.055	102
103	22.958	1.109	2123.337	0.5754	6236.47	26161.22	0.01317	4.144	103
104	23.958	1.182	2143.277	0.5733	6317.23	26403.90	0.01320	4.233	104
105	24.978	1.258	2160.492	0.5713	6390.51	26612.89	0.01323	4.321	105
106	26.020	1.338	2174.781	0.5693	6455.61	26785.73	0.01326	4.410	106
107	27.082	1.421	2185.862	0.5673	6511.61	26918.96	0.01329	4.499	107
108	28.165	1.507	2193.493	0.5653	6557.67	27009.62	0.01332	4.588	108
109	29.266	1.596	2197.452	0.5632	6593.00	27054.99	0.01336	4.676	109
110	30.388	1.689	2197.534	0.5612	6616.88	27052.55	0.01339	4.765	110
111	31.528	1.784	2193.549	0.5592	6628.59	27000.00	0.01342	4.853	111
112	32.685	1.884	2185.378	0.5572	6627.63	26895.89	0.01345	4.941	112

113	33.861	1.988	2172.902	0.5552	6613.48	26738.78	0.01348	5.028	113
114	35.852	2.042	2156.113	0.5532	6585.98	26528.60	0.01351	5.115	114
115	37.859	2.201	2135.062	0.5513	6545.11	26265.98	0.01354	5.202	115
116	39.881	2.313	2109.785	0.5493	6490.84	25951.44	0.01357	5.289	116
117	41.917	2.442	2080.446	0.5473	6423.52	25587.00	0.01360	5.375	117
118	43.966	2.547	2047.353	0.5454	6343.95	25176.39	0.01363	5.460	118
119	46.029	2.663	2010.753	0.5434	6252.76	24722.80	0.01366	5.545	119
120	48.107	2.793	1970.978	0.5415	6150.86	24230.27	0.01369	5.629	120
121	50.178	2.920	1928.573	0.5396	6039.84	23705.53	0.01372	5.713	121
122	52.268	3.050	1883.956	0.5377	5920.92	23153.72	0.01376	5.796	122
123	54.366	3.182	1837.709	0.5358	5795.85	22582.04	0.01379	5.878	123
124	56.471	3.318	1790.386	0.5340	5666.31	21997.28	0.01382	5.960	124
125	58.582	3.456	1742.733	0.5321	5534.65	21408.62	0.01385	6.041	125
126	60.699	3.596	1695.316	0.5303	5402.66	20823.04	0.01388	6.121	126
127	62.821	3.734	1648.787	0.5285	5272.42	20248.50	0.01391	6.200	127
128	64.948	3.886	1603.825	0.5267	5146.15	19693.37	0.01394	6.278	128
129	67.079	4.031	1561.062	0.5249	5025.94	19165.41	0.01397	6.356	129
130	69.215	4.181	1521.026	0.5231	4913.57	18671.07	0.01400	6.433	130
131	71.356	4.333	1484.141	0.5214	4810.68	18216.14	0.01403	6.510	131
132	73.502	4.487	1451.213	0.5196	4719.51	17808.69	0.01406	6.586	132
133	75.653	4.644	1422.133	0.5179	4640.34	17449.16	0.01409	6.661	133
134	77.811	4.804	1397.314	0.5162	4574.49	17142.02	0.01412	6.736	134
135	79.976	4.966	1376.735	0.5145	4522.03	16886.96	0.01416	6.810	135
136	82.150	5.131	1360.412	0.5128	4483.18	16684.16	0.01419	6.884	136
137	84.332	5.299	1347.881	0.5111	4456.55	16527.91	0.01422	6.957	137
138	86.525	5.469	1339.074	0.5094	4442.05	16417.34	0.01425	7.030	138
139	87.928	5.644	1332.961	0.5078	4436.38	16339.81	0.01428	7.103	139
140	89.343	5.821	1328.727	0.5061	4436.91	16285.32	0.01431	7.176	140
141	90.771	6.001	1325.961	0.5044	4442.35	16246.80	0.01434	7.249	141
142	92.211	6.185	1322.577	0.5027	4445.71	16204.71	0.01437	7.322	142
143	93.662	6.373	1317.658	0.5011	4443.89	16141.81	0.01440	7.394	143
144	95.122	6.564	1309.367	0.4994	4430.53	16037.36	0.01443	7.466	144
145	96.589	6.756	1296.205	0.4978	4400.61	15873.78	0.01446	7.538	145
146	98.063	6.952	1276.115	0.4961	4346.71	15625.18	0.01449	7.609	146
147	99.546	7.149	1247.384	0.4945	4262.75	15270.87	0.01453	7.679	147
148	00.982	7.345	1206.370	0.4929	4142.77	14790.83	0.01456	7.748	148
149	02.416	7.542	1156.907	0.4914	3978.88	14156.62	0.01459	7.816	149
150	03.814	7.735	1091.412	0.4899	3765.14	13354.98	0.01462	7.881	150
151	05.160	7.922	1010.940	0.4884	3497.77	12368.43	0.01465	7.943	151



X-INCREMENT= 0.898535E+00 Y-INCREMENT= 0.451830E+02
X-SCALE IS 0.898535E+01 PER INCH Y-SCALE IS 0.271098E+03 PER INCH


GRAPH OF TORQUE VS TIME
2197.53394
1745.70386
1293.87374
842.04370
390.21362
-61.61646
0.0
0.00146
0.00293
0.00439
0.00586
0.00732
0.00879
0.01025
0.01172
0.01318
0.01465
X-INCREMENT= 0.146485E-03
X-SCALE IS 0.146485E-02 PER INCH
Y-INCREMENT= 0.451830E+02
Y-SCALE IS 0.271098E+03 PER INCH

CONSTANT TWIST CHANNEL

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permit fully legible reproduction

CONSTANT TWIST BARREL

J	POSITION (INCHES)	Y (INCHES)	TORQUE (IN-LBS)	SHEAR AREA (INCHES**2)	SHEAR STRESS (PSI)	BEARING STRESS (PSI)	TIME (SECONDS)	RIFLING ANGLE (DEGREES)	J
1	-4.692	0.0	0.0	**********	0.0	0.0	0.0	0.0	1
2	-4.684	0.0	0.0	**********	0.0	0.0	0.00010	0.0	2
3	-4.675	0.0	0.0	**********	0.0	0.0	0.00020	0.0	3
4	-4.665	0.0	0.0	**********	0.0	0.0	0.00030	0.0	4
5	-4.587	0.0	0.0	**********	0.0	0.0	0.00040	0.0	5
6	-4.505	0.0	0.0	**********	0.0	0.0	0.00050	0.0	6
7	-4.396	0.0	0.0	**********	0.0	0.0	0.00060	0.0	7
8	-4.260	0.0	0.0	**********	0.0	0.0	0.00070	0.0	8
9	-4.097	0.0	0.0	**********	0.0	0.0	0.00080	0.0	9
10	-3.909	0.0	0.0	**********	0.0	0.0	0.00090	0.0	10
11	-3.696	0.0	0.0	**********	0.0	0.0	0.00100	0.0	11
12	-3.462	0.0	0.0	**********	0.0	0.0	0.00110	0.0	12
13	-3.208	0.0	0.0	**********	0.0	0.0	0.00120	0.0	13
14	-2.937	0.0	0.0	**********	0.0	0.0	0.00130	0.0	14
15	-2.651	0.0	0.0	**********	0.0	0.0	0.00140	0.0	15
16	-2.354	.	0.0	**********	0.0	0.0	0.00150	0.0	16
17	-2.049	0.0	0.0	**********	0.0	0.0	0.00160	0.0	17
18	-1.736	0.0	0.0	**********	0.0	0.0	0.00170	0.0	18
19	-1.419	0.0	0.0	**********	0.0	0.0	0.00180	0.0	19
20	-1.098	0.0	0.0	**********	0.0	0.0	0.00190	0.0	20
21	-0.777	0.0	0.0	**********	0.0	0.0	0.00200	0.0	21
22	-0.455	0.0	0.0	**********	0.0	0.0	0.00210	0.0	22
23	-0.134	0.0	0.0	**********	0.0	0.0	0.00220	0.0	23
24	0.186	0.0	0.0	**********	0.0	0.0	0.00230	0.0	24
25	0.503	0.0	0.0	**********	0.0	0.0	0.00240	0.0	25
26	0.816	0.0	0.0	**********	0.0	0.0	0.00250	0.0	26
27	1.124	0.020	-57.163	0.6693	-144.24	-529.74	0.00260	8.967	27
28	1.425	0.067	-74.075	0.6693	-187.04	-686.94	0.00270	8.967	28
29	1.719	0.113	-94.869	0.6693	-239.55	-879.76	0.00280	8.967	29
30	2.002	0.158	-119.709	0.6693	-302.27	-1110.14	0.00290	8.967	30
31	2.271	0.201	-148.523	0.6693	-375.03	-1377.35	0.00300	8.967	31
32	2.525	0.241	-180.665	0.6693	-456.19	-1675.41	0.00310	8.967	32
33	2.759	0.274	-215.034	0.6693	-542.97	-1994.14	0.00320	8.967	33
34	2.970	0.311	-249.944	0.6693	-631.12	-2317.88	0.00330	8.967	34
35	3.154	0.340	-283.319	0.6693	-715.40	-2627.39	0.00340	8.967	35
36	3.310	0.364	-312.336	0.6693	-788.67	-2896.48	0.00350	8.967	36
37	3.433	0.384	-334.065	0.6693	-843.53	-3097.99	0.00360	8.967	37
38	3.523	0.399	-345.110	0.6693	-871.42	-3200.42	0.00370	8.967	38
39	3.579	0.407	-342.068	0.6693	-863.74	-3172.21	0.00380	8.967	39
40	3.602	0.411	-321.909	0.6693	-812.84	-2985.26	0.00390	8.967	40
41	3.595	0.410	73.037	0.6693	184.42	677.32	0.00400	8.967	41
42	3.600	0.442	0.0	0.6693	0.0	0.0	0.00515	8.967	42
43	3.800	0.442	0.0	0.6693	0.0	0.0	0.00540	8.967	43
44	3.800	0.442	0.0	0.6693	0.0	0.0	0.00570	8.967	44
45	3.800	0.442	0.0	0.6693	0.0	0.0	0.00600	8.967	45
46	3.800	0.442	0.0	0.6693	0.0	0.0	0.00630	8.967	46
47	3.800	0.442	0.0	0.6693	0.0	0.0	0.00660	8.967	47
48	3.800	0.442	0.0	0.6693	0.0	0.0	0.00690	8.967	48
49	3.800	0.442	0.0	0.6693	0.0	0.0	0.00720	8.967	49
50	3.800	0.442	0.0	0.6693	0.0	0.0	0.00750	8.967	50
51	3.800	0.442	0.0	0.6693	0.0	0.0	0.00780	8.967	51
52	3.800	0.442	0.0	0.6693	0.0	0.0	0.00810	8.967	52

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53	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.00840	0.967	53
54	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.00870	0.967	54
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58	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.00990	0.967	58
59	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.01020	0.967	59
60	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.01050	0.967	60
61	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.01080	0.967	61
62	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.01110	0.967	62
63	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.01140	0.967	63
64	3.800	[illegible]	0.0	0.0693	0.0	0.0	0.01170	0.967	64
65	[illegible]	[illegible]	0.0	0.0693	0.0	0.0	0.01200	0.967	65
66	[illegible]	[illegible]	588.617	0.0693	14n1.24	5440.06	0.01203	0.967	66
67	[illegible]	[illegible]	1094.307	0.0693	2763.19	10148.20	0.01206	0.967	67
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69	[illegible]	[illegible]	1939.219	0.0693	4896.64	17983.57	0.01212	0.967	69
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79	[illegible]	[illegible]	3574.215	0.0693	9025.09	33145.89	0.01243	0.967	79
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84	[illegible]	[illegible]	3457.862	0.0693	8731.35	32067.07	0.01259	0.967	84
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87	10.107	[illegible]	3281.040	0.0693	8284.81	30427.09	0.01268	0.967	87
88	10.713	[illegible]	3214.[illegible]59	0.0693	8118.05	29814.84	0.01271	0.967	88
89	11.356	[illegible]	3147.[illegible]38	0.0693	7947.71	29189.05	0.01274	0.967	89
90	12.027	[illegible]	3079.[illegible]65	0.0693	7776.22	28559.25	0.01277	0.967	90
91	12.722	[illegible]	3012.[illegible]59	0.0693	7605.61	27932.65	0.01280	0.967	91
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94	14.962	[illegible]	2816.[illegible]76	0.0693	7112.25	26120.73	0.01289	0.967	94
95	15.758	[illegible]	2754.[illegible]68	0.0693	6956.45	25548.50	0.01292	0.967	95
96	16.578	[illegible]	2695.[illegible]58	0.0693	6805.27	24993.30	0.01295	0.967	96
97	17.421	[illegible]	2638.[illegible]27	0.0693	6658.53	24454.35	0.01299	0.967	97
98	18.288	[illegible]	2584.[illegible]43	0.0693	6515.76	23930.02	0.01302	0.967	98
99	19.177	[illegible]	2532.[illegible]59	0.0693	6376.27	23417.72	0.01305	0.967	99
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103	22.958	[illegible]	2309.965	0.0693	5832.79	21421.72	0.01317	0.967	103
104	23.958	[illegible]	2255.[illegible]24	0.0693	5695.34	20916.91	0.01320	0.967	104
105	24.978	[illegible]	2199.958	0.0693	5555.02	20401.56	0.01323	0.967	105
106	26.020	[illegible]	2142.[illegible]19	0.0693	5410.99	19872.61	0.01326	0.967	106
107	27.082	[illegible]	2084.[illegible]19	0.0693	5262.27	19326.39	0.01329	0.967	107
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109	29.266	[illegible]	1959.[illegible]69	0.0693	4947.77	18171.37	0.01336	0.967	109
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112	32.[illegible]	[illegible]	1753.064	0.0693	4426.59	16257.24	0.01345	0.967	112

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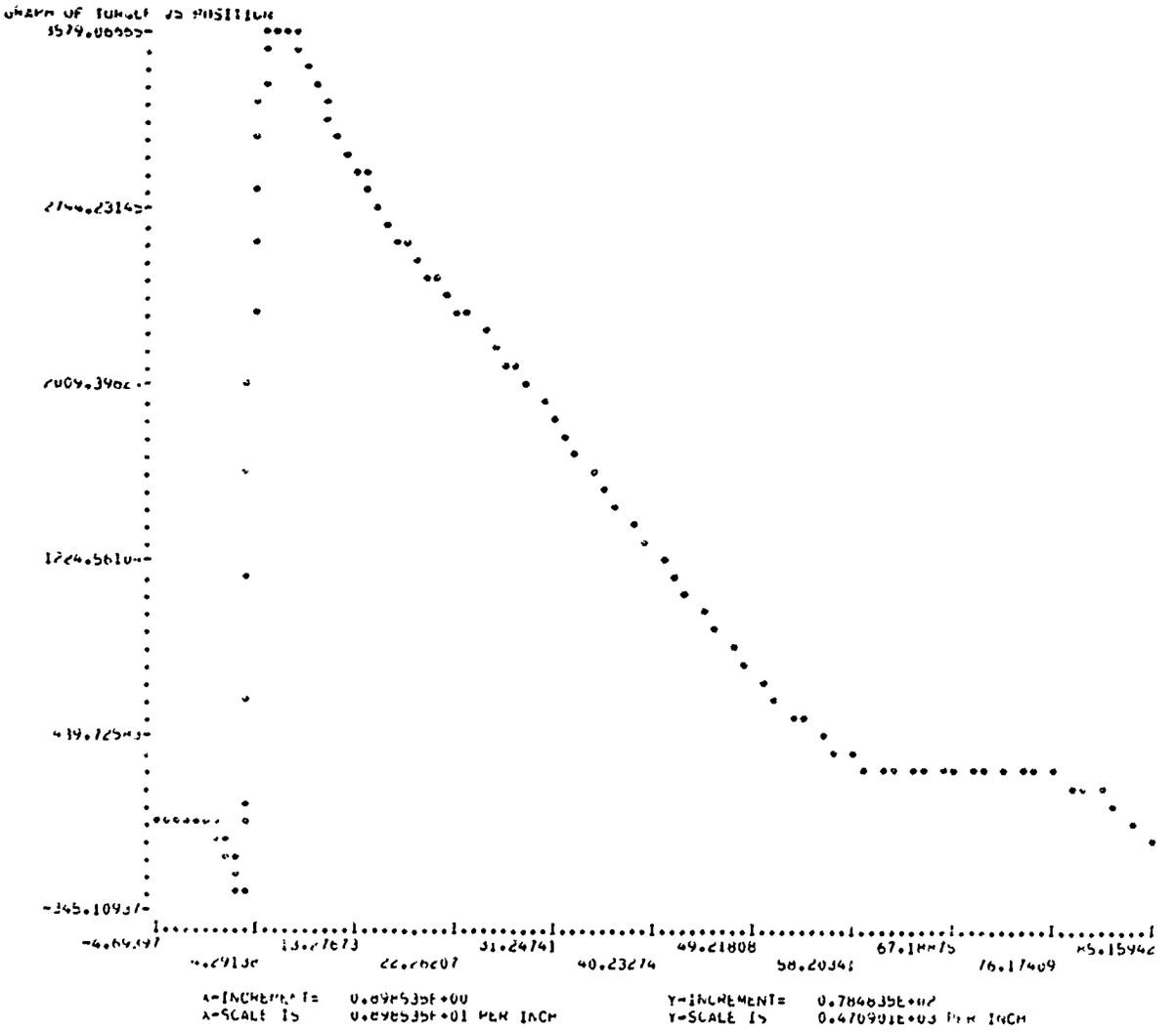
113	33.881	5.145	1677.965	0.0693	4239.38	15588.59	0.01348	8.967	113
114	35.952	5.371	1601.973	0.0693	4045.07	14856.04	0.01351	8.967	114
115	36.254	5.566	1522.463	0.0693	3845.21	14122.07	0.01354	8.967	115
116	37.401	5.756	1441.575	0.0693	3640.06	13368.61	0.01357	8.967	116
117	38.717	5.951	1359.619	0.0693	3430.59	12599.31	0.01360	8.967	117
118	39.944	6.144	1274.478	0.0693	3216.13	11819.02	0.01363	8.967	118
119	41.225	6.347	1189.522	0.0693	3003.80	11032.10	0.01366	8.967	119
120	42.497	6.543	1104.577	0.0693	2789.12	10243.42	0.01369	8.967	120
121	43.778	6.740	1020.082	0.0693	2575.77	9459.85	0.01372	8.967	121
122	45.048	6.936	936.718	0.0693	2365.26	8686.74	0.01376	8.967	122
123	46.300	7.129	855.199	0.0693	2159.42	7930.78	0.01379	8.967	123
124	47.671	7.340	776.164	0.0693	1959.91	7198.03	0.01382	8.967	124
125	48.982	7.571	700.459	0.0693	1768.79	6496.13	0.01385	8.967	125
126	50.295	7.779	628.716	0.0693	1587.54	5830.46	0.01388	8.967	126
127	51.671	7.987	561.474	0.0693	1417.75	5206.89	0.01391	8.967	127
128	52.944	8.197	499.394	0.0693	1261.00	4631.18	0.01394	8.967	128
129	54.279	8.407	443.004	0.0693	1118.61	4108.25	0.01397	8.967	129
130	55.615	8.618	392.670	0.0693	991.51	3641.47	0.01400	8.967	130
131	56.956	8.829	348.069	0.0693	880.41	3233.42	0.01403	8.967	131
132	58.302	9.041	311.446	0.0693	786.42	2888.25	0.01406	8.967	132
133	59.653	9.255	280.755	0.0693	708.92	2603.61	0.01409	8.967	133
134	61.011	9.469	256.028	0.0693	648.08	2380.15	0.01412	8.967	134
135	62.376	9.684	236.754	0.0693	602.97	2214.49	0.01416	8.967	135
136	63.750	9.901	220.944	0.0693	572.79	2103.67	0.01419	8.967	136
137	65.132	10.119	219.968	0.0693	555.43	2039.90	0.01422	8.967	137
138	66.525	10.339	217.730	0.0693	549.78	2019.15	0.01425	8.967	138
139	67.928	10.560	218.732	0.0693	552.31	2028.44	0.01428	8.967	139
140	69.343	10.784	221.760	0.0693	560.02	2056.76	0.01431	8.967	140
141	70.771	11.009	226.177	0.0693	571.11	2097.48	0.01434	8.967	141
142	72.211	11.236	229.508	0.0693	579.52	2128.37	0.01437	8.967	142
143	73.662	11.465	230.613	0.0693	582.31	2138.62	0.01440	8.967	143
144	75.122	11.696	227.447	0.0693	574.32	2109.25	0.01443	8.967	144
145	76.589	11.927	218.415	0.0693	551.51	2025.49	0.01446	8.967	145
146	78.060	12.159	201.387	0.0693	508.46	1867.40	0.01449	8.967	146
147	79.529	12.391	174.592	0.0693	440.86	1619.10	0.01453	8.967	147
148	80.982	12.620	136.257	0.0693	344.81	1266.38	0.01456	8.967	148
149	82.416	12.849	85.285	0.0693	215.35	790.90	0.01459	8.967	149
150	83.814	13.067	19.379	0.0693	48.93	179.71	0.01462	8.967	150
151	85.168	13.279	-61.818	0.0693	-156.10	-573.28	0.01465	8.967	151



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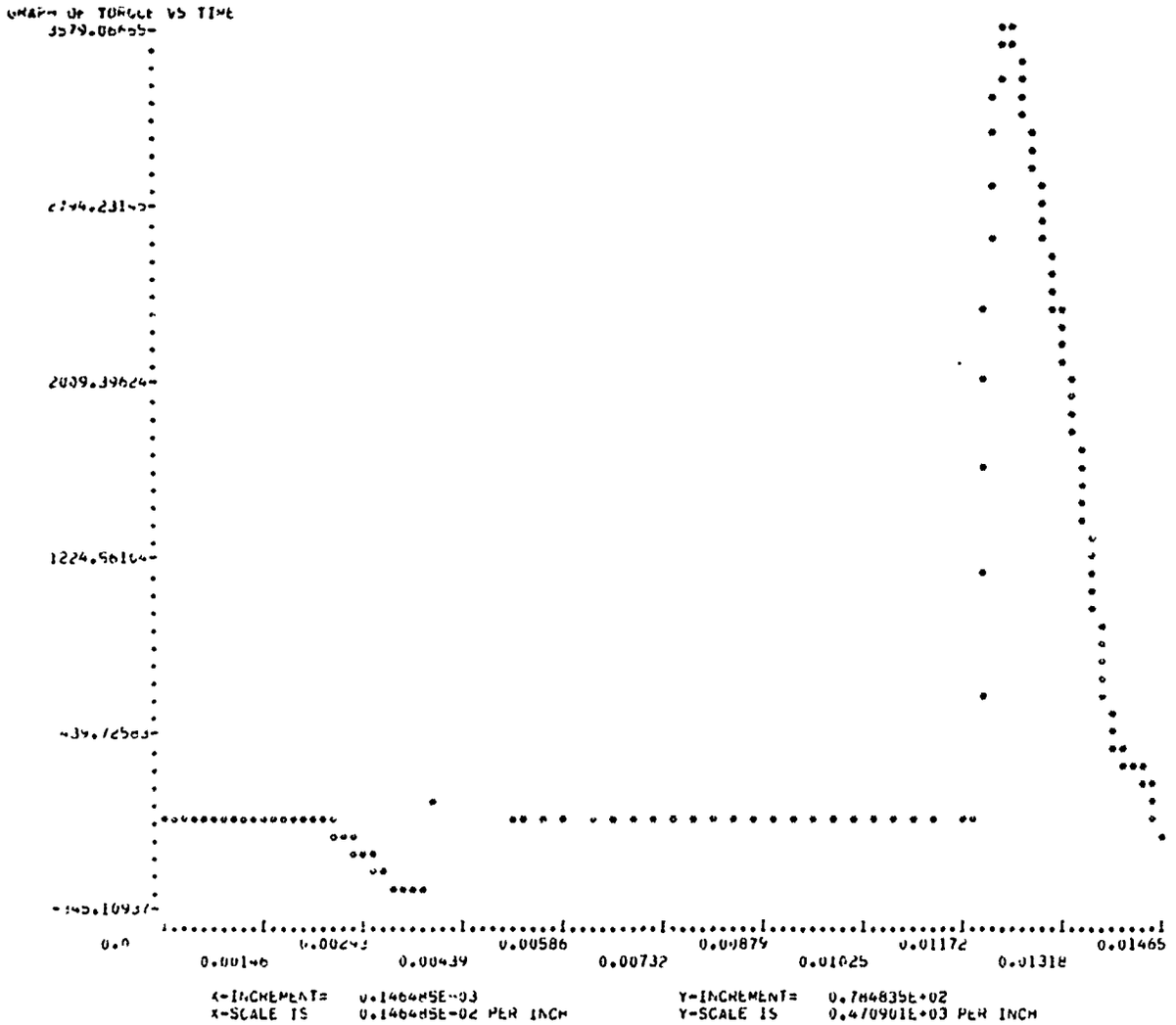

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INTEGRAL VALUES					
TORQUE		SHEAR STRESS		BEARING STRESS	
UNIT TIME (IN-LB-SEC)	UNIT POSITION (IN-LB-IN)	UNIT TIME (PSI-SEC)	UNIT POSITION (PSI-IN)	UNIT TIME (PSI-SEC)	UNIT POSITION (PSI-IN)
N=1.0 BARREL					
0.4473643E+01	0.1472466E+06	0.1253500E+02	0.4210487E+06	0.4176937E+02	0.1373403E+07
N=1.5 BARREL					
0.4475106E+01	0.1592115E+06	0.1248706E+02	0.4277394E+06	0.4177975E+02	0.1401388E+07
N=2.0 BARREL					
0.4474454E+01	0.1514926E+06	0.1246112E+02	0.4317634E+06	0.4178682E+02	0.1418066E+07
HERCULES BARREL					
0.4488925E+01	0.1346991E+06	0.1210472E+02	0.4176750E+06	0.4907883E+02	0.1656044E+07
CONSTANT TAPER BARREL					
0.4307442E+01	0.1044879E+06	0.1087657E+02	0.2638393E+06	0.3994536E+02	0.9685911E+06
NEW BARREL					
0.4510077E+01	0.1671994E+06	0.1377387E+02	0.5202468E+06	0.5534512E+02	0.2049215E+07

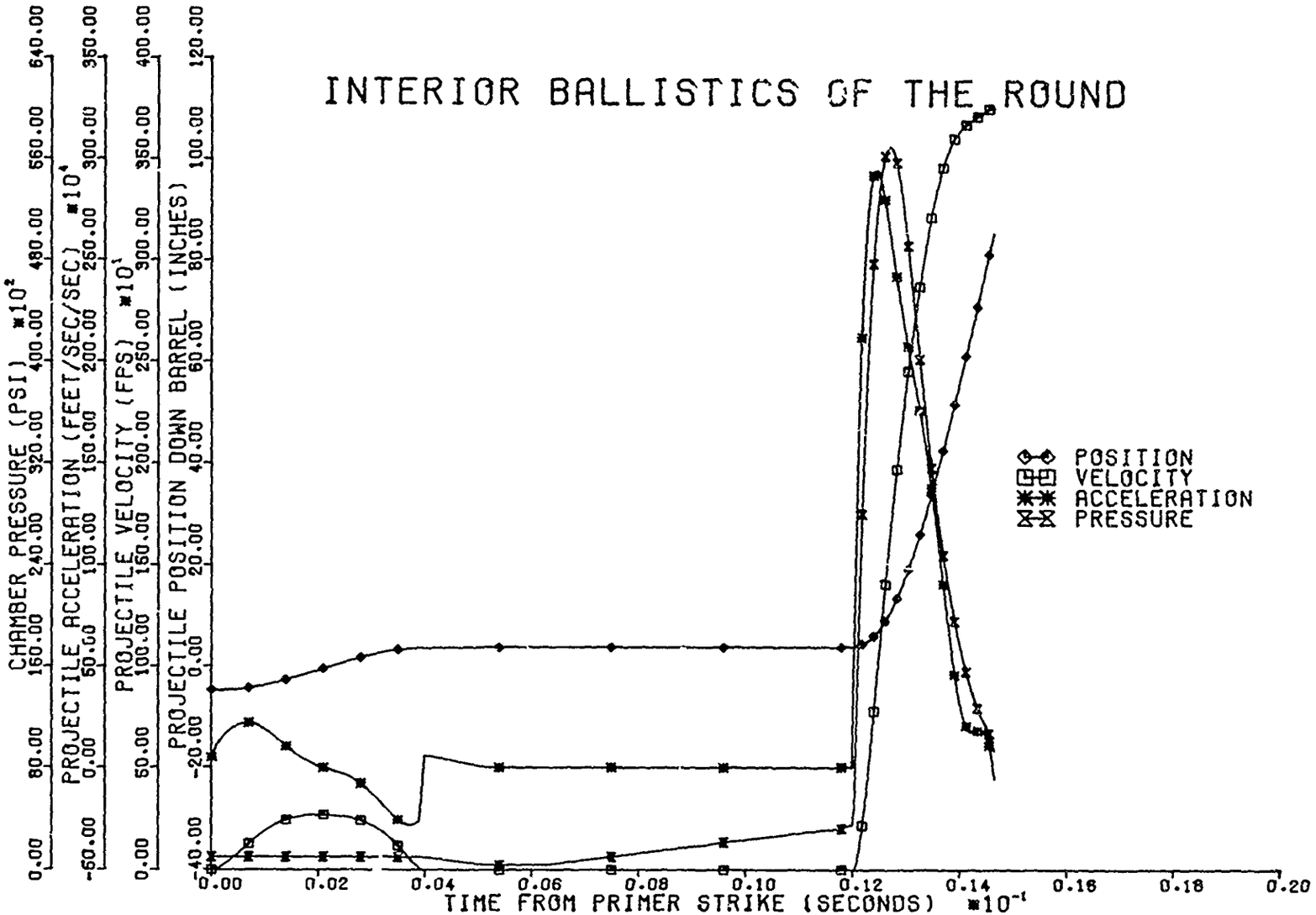
INTERIOR BALLISTICS OF THE ROUND
CHAMBER PRESSURE (PSI) *10²
PROJECTILE ACCELERATION (FEET/SEC/SEC) *10⁴
PROJECTILE VELOCITY (FPS) *10¹
PROJECTILE POSITION DOWN BARREL (INCHES)
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹
POSITION
VELOCITY
ACCELERATION
PRESSURE

FIGURE A-1

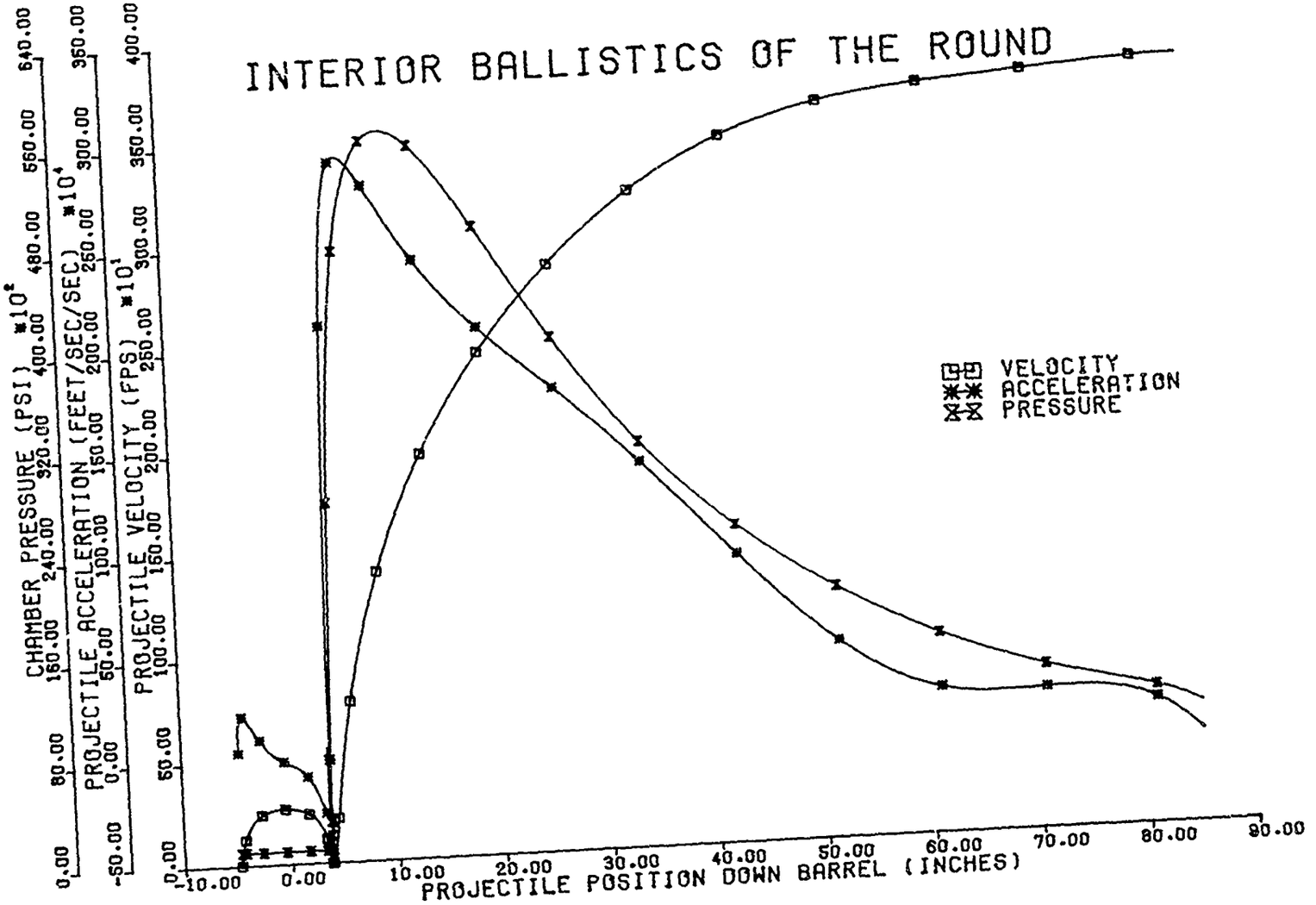
INTERIOR BALLISTICS OF THE ROUND
CHAMBER PRESSURE (PSI) *10²
PROJECTILE ACCELERATION (FEET/SEC/SEC) *10⁴
PROJECTILE VELOCITY (FPS) *10¹
PROJECTILE POSITION DOWN BARREL (INCHES)
VELOCITY
ACCELERATION
PRESSURE

FIGURE A-2

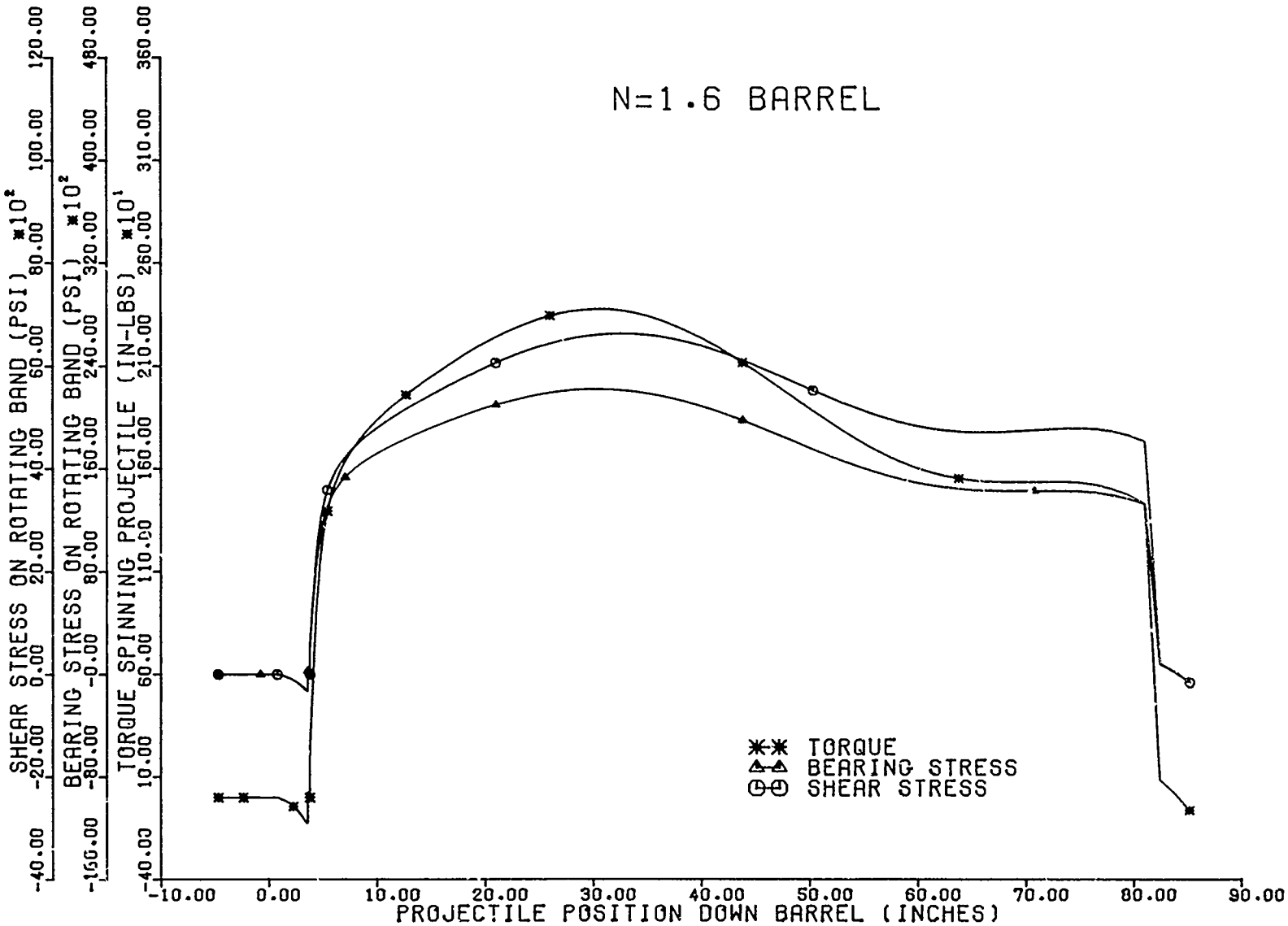
N=1.6 BARREL
SHEAR STRESS ON ROTATING BAND (PSI) *10²
BEARING STRESS ON ROTATING BAND (PSI) *10²
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
-20.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
-160.00
-80.00
-0.00
80.00
160.00
240.00
320.00
400.00
480.00
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)
TORQUE
BEARING STRESS
SHEAR STRESS

FIGURE A-3

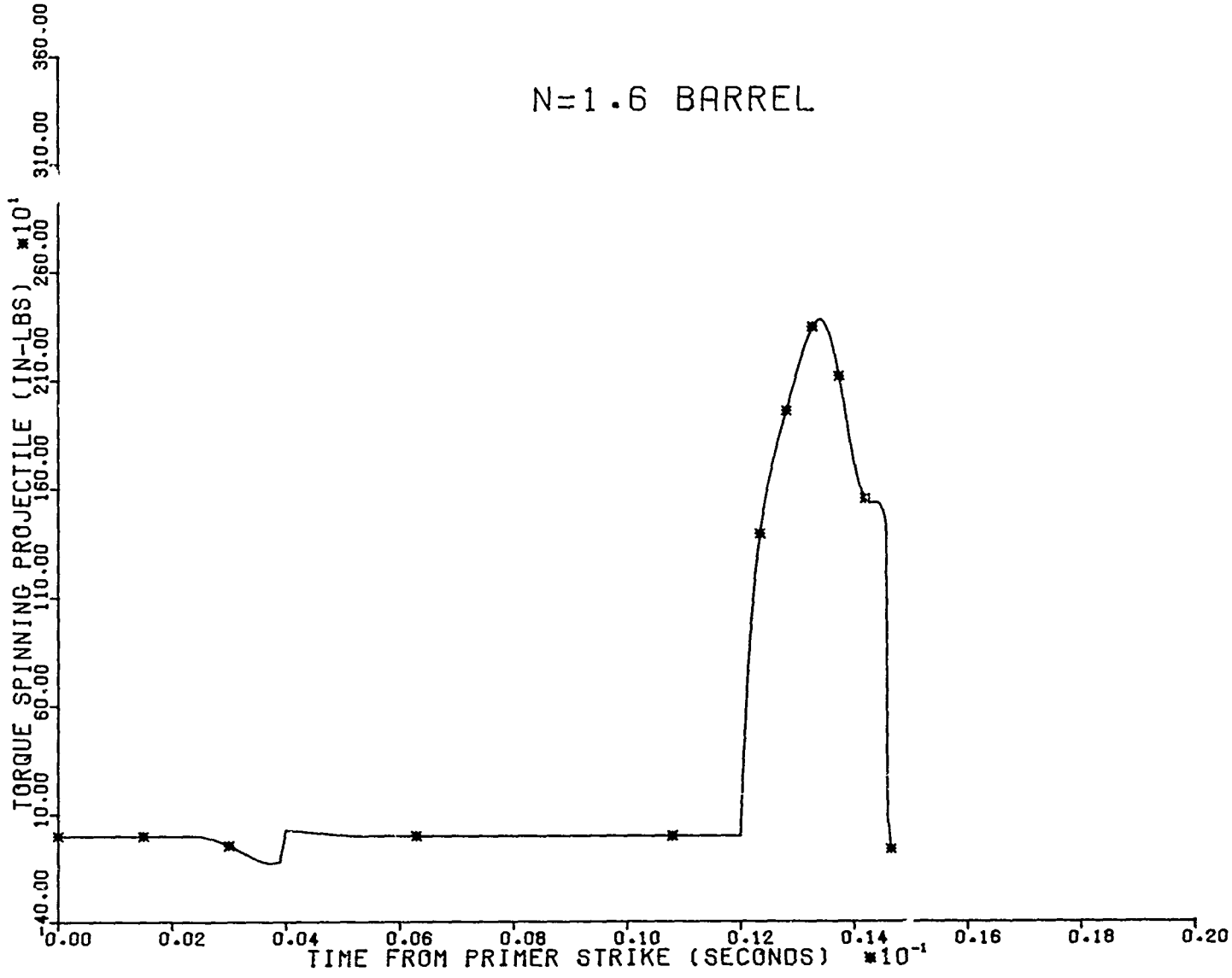
N=1.6 BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹

FIGURE A-4

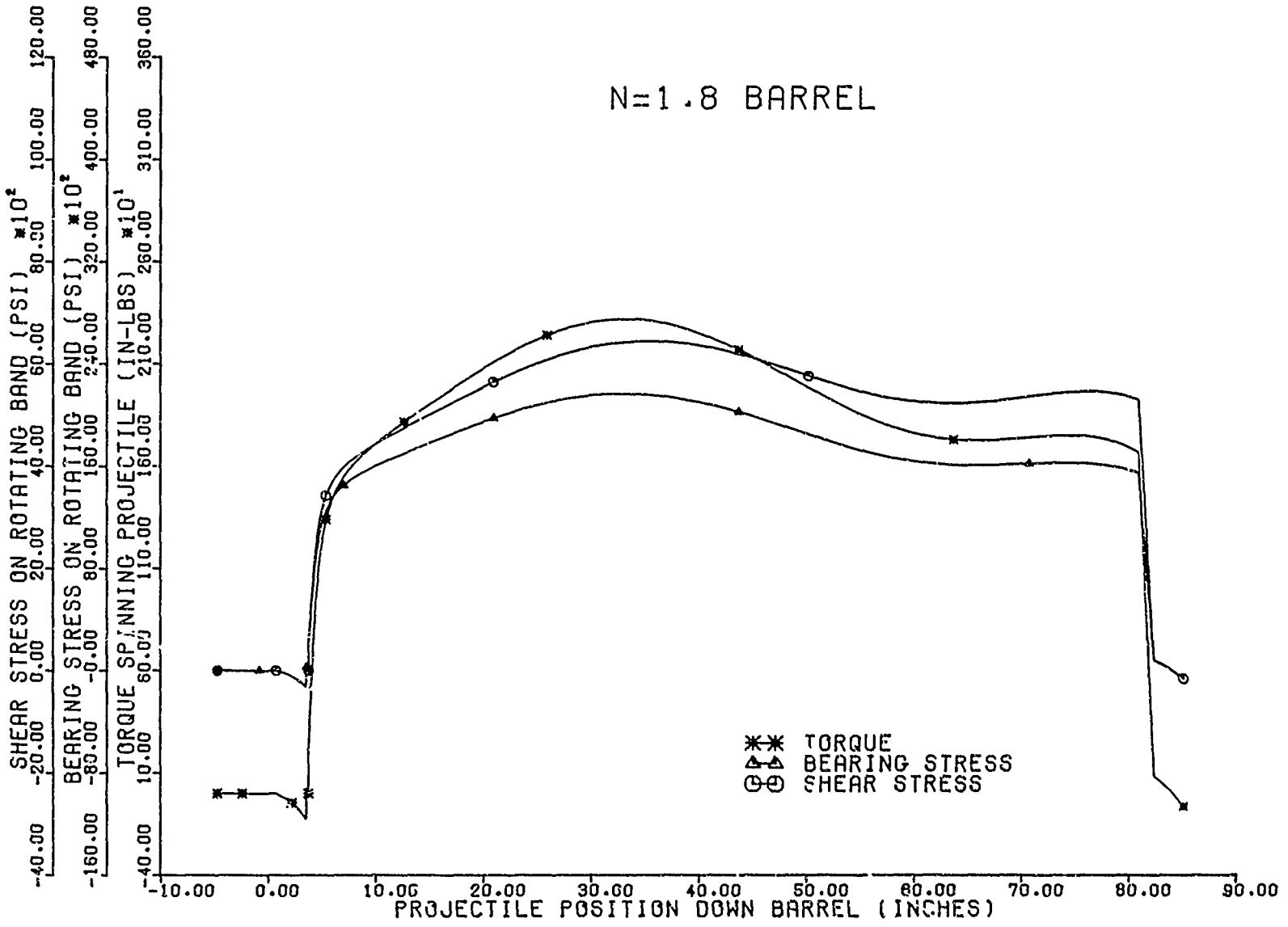
N=1.8 BARREL
SHEAR STRESS ON ROTATING BAND (PSI) *10²
BEARING STRESS ON ROTATING BAND (PSI) *10²
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00 -20.00 0.00 20.00 40.00 60.00 80.00 100.00 120.00
-160.00 -80.00 -0.00 80.00 160.00 240.00 320.00 400.00 480.00
-40.00 10.00 60.00 110.00 160.00 210.00 260.00 310.00 360.00
-10.00 0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00
PROJECTILE POSITION DOWN BARREL (INCHES)
TORQUE
BEARING STRESS
SHEAR STRESS

FIGURE A-5

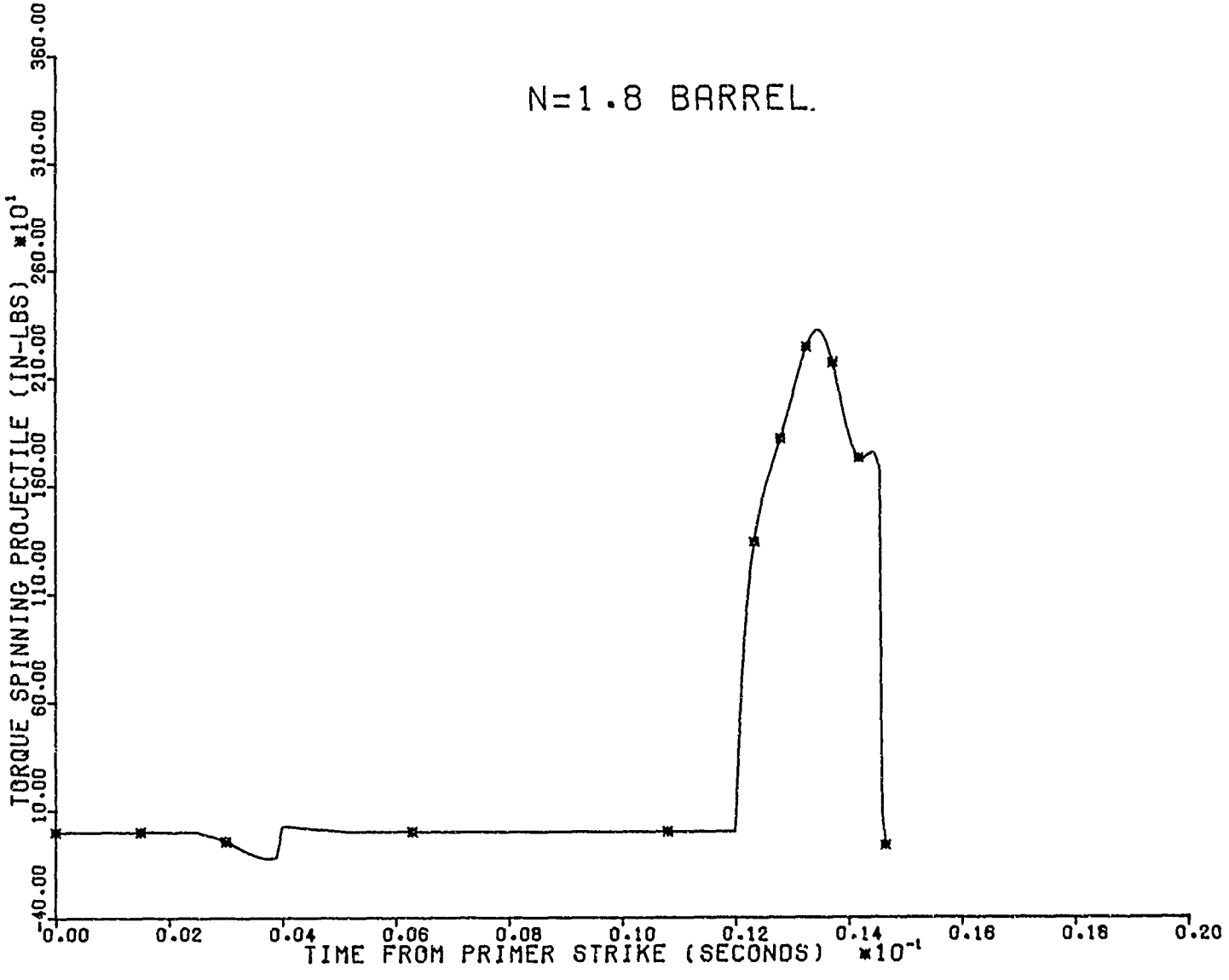
N=1.8 BARREL.
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
360.00
310.00
260.00
210.00
160.00
110.00
60.00
10.00
-40.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹

FIGURE A-6

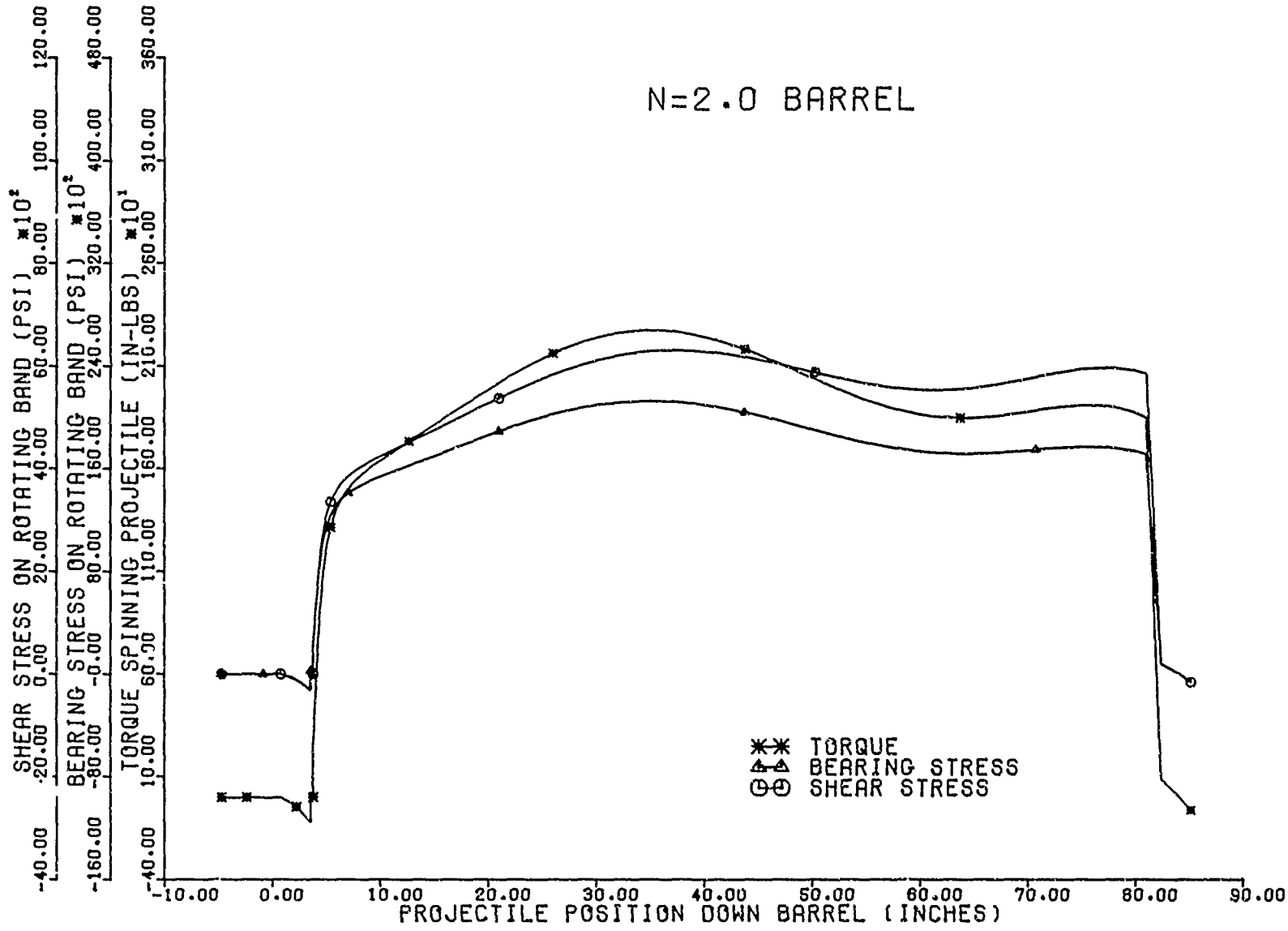
N=2.0 BARREL
SHEAR STRESS ON ROTATING BAND (PSI) *10²
BEARING STRESS ON ROTATING BAND (PSI) *10²
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
-20.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
-160.00
-80.00
-0.00
80.00
160.00
240.00
320.00
400.00
480.00
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)
TORQUE
BEARING STRESS
SHEAR STRESS

FIGURE A-7

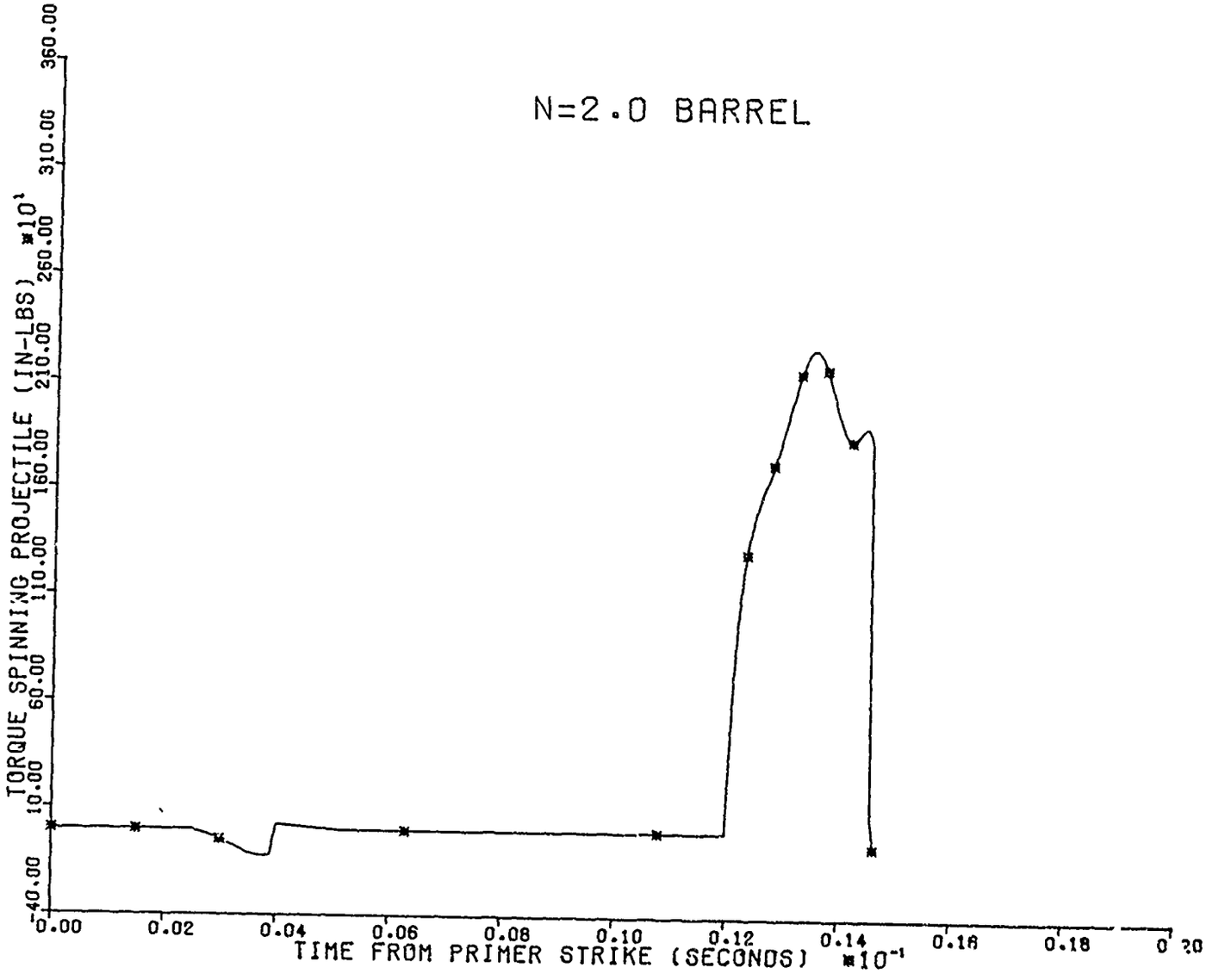
N=2.0 BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹

FIGURE A-8

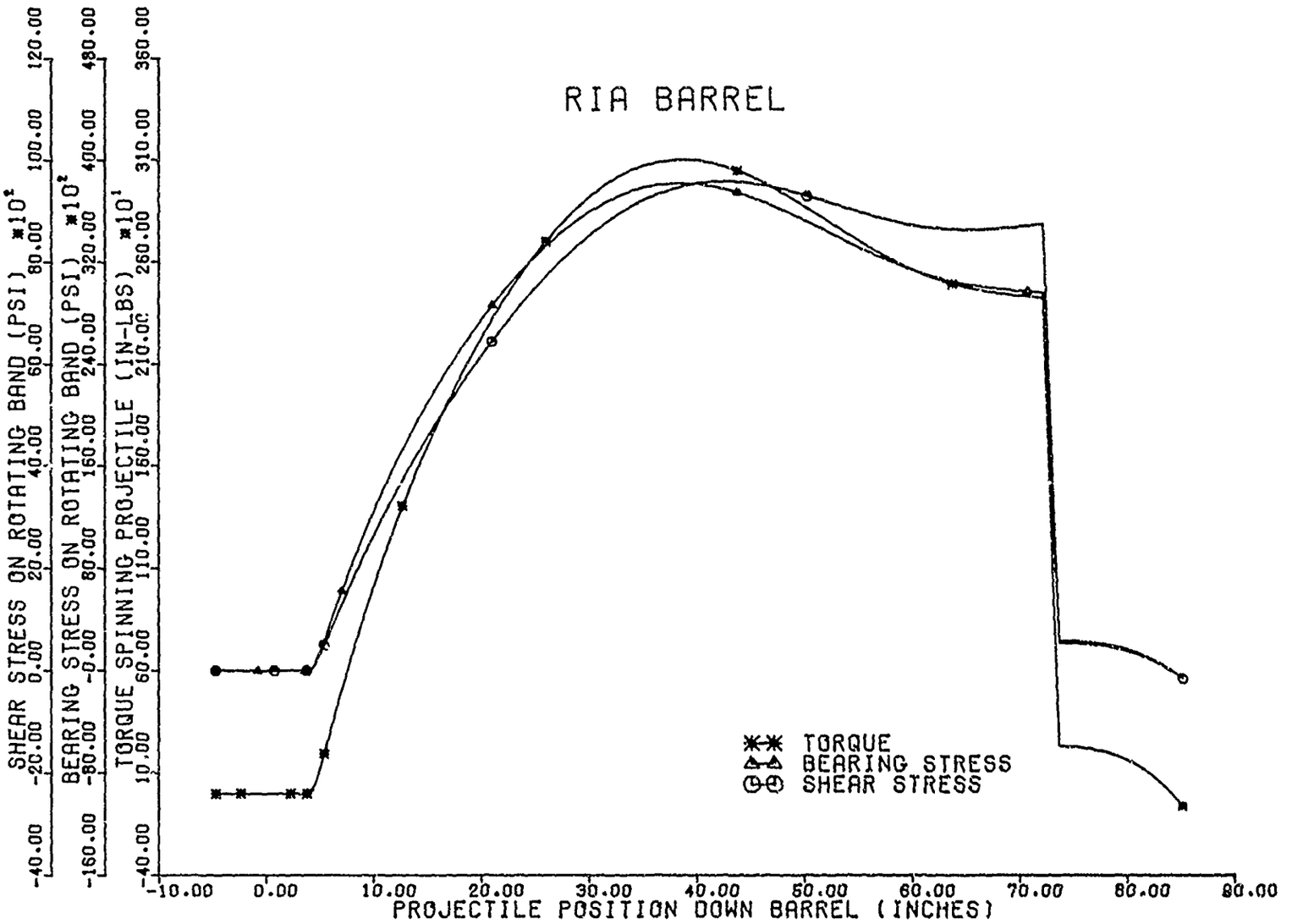
RIA BARREL
SHEAR STRESS ON ROTATING BAND (PSI) *10²
BEARING STRESS ON ROTATING BAND (PSI) *10²
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
-20.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
-160.00
-80.00
-0.00
80.00
160.00
240.00
320.00
400.00
480.00
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)
TORQUE
BEARING STRESS
SHEAR STRESS

FIGURE A-9

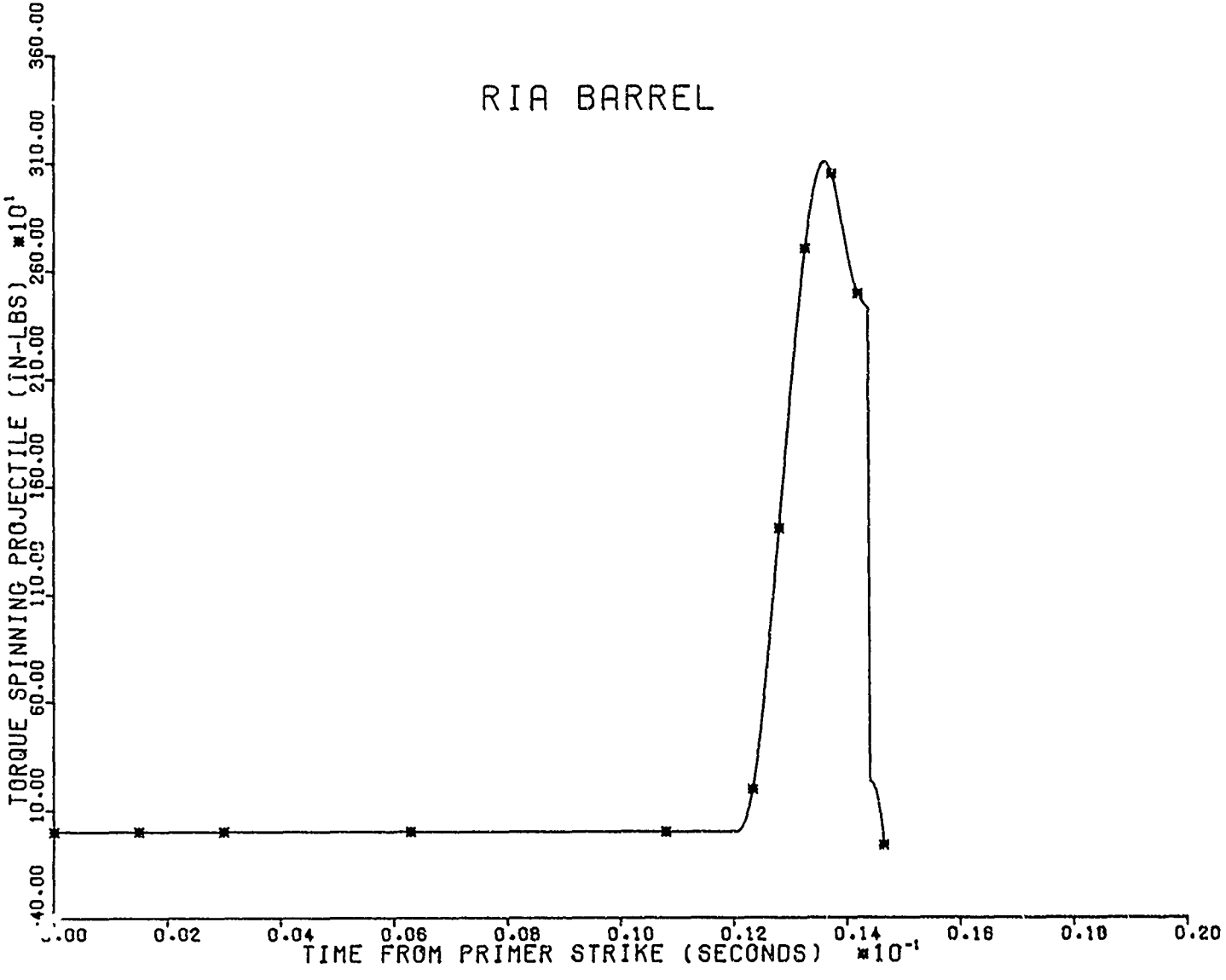
RIA BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹

FIGURE A-10

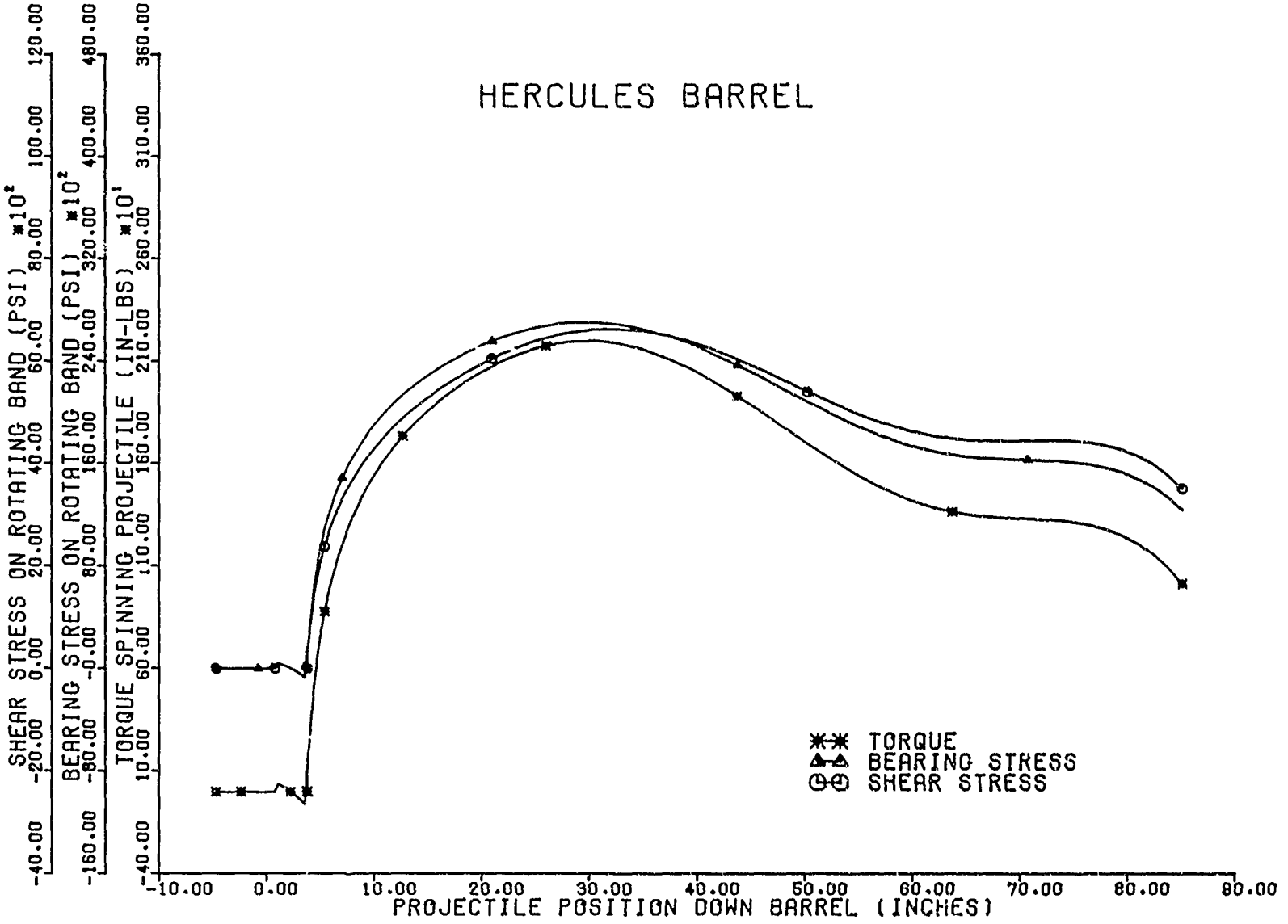
HERCULES BARREL
SHEAR STRESS ON ROTATING BAND (PSI) *10²
BEARING STRESS ON ROTATING BAND (PSI) *10²
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00 -20.00 0.00 20.00 40.00 60.00 80.00 100.00 120.00
-160.00 -80.00 -0.00 80.00 160.00 240.00 320.00 400.00 480.00
-40.00 10.00 60.00 110.00 160.00 210.00 260.00 310.00 360.00
-10.00 0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00
PROJECTILE POSITION DOWN BARREL (INCHES)
TORQUE
BEARING STRESS
SHEAR STRESS

FIGURE A-11

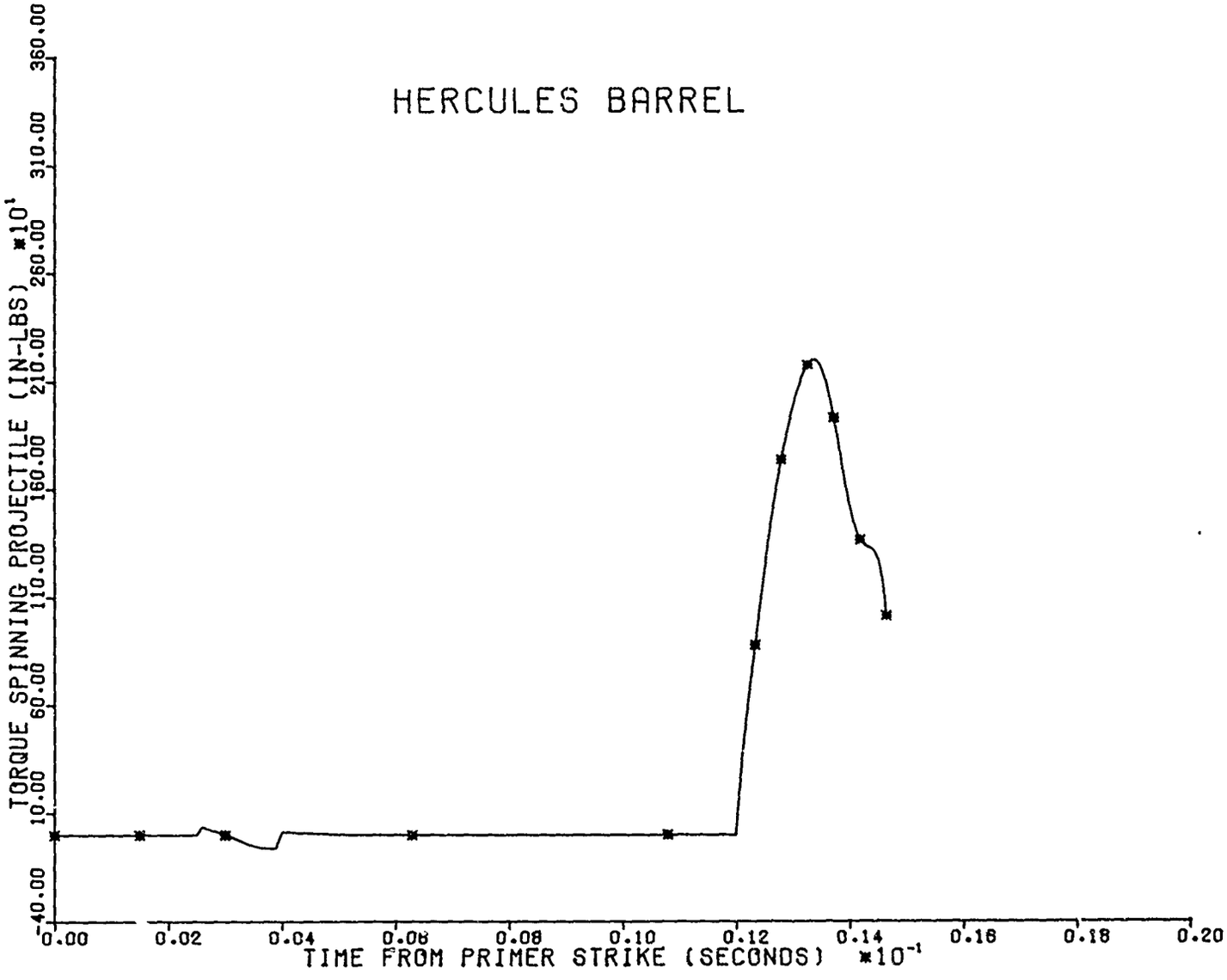
HERCULES BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹

FIGURE A-12

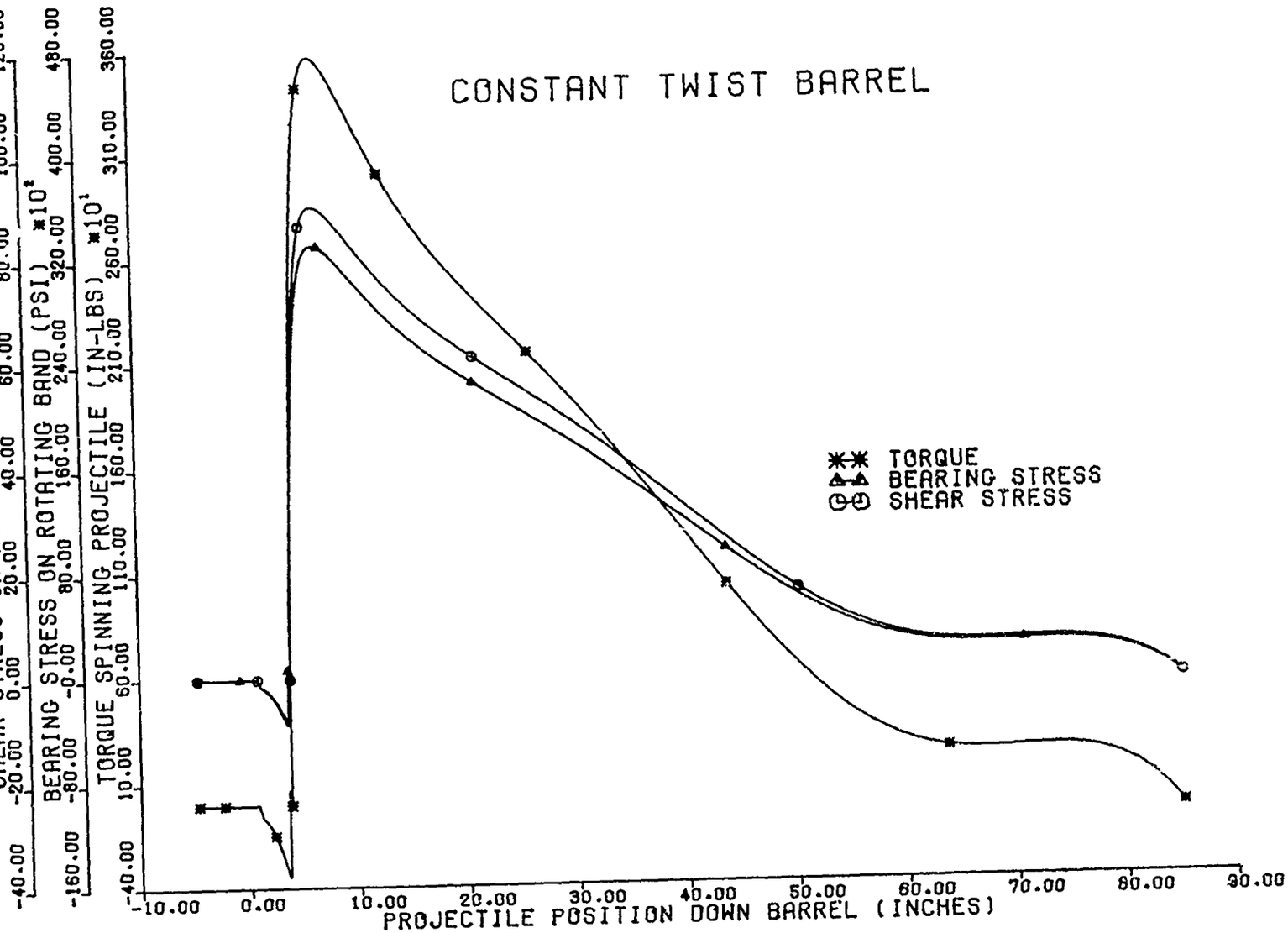
CONSTANT TWIST BARREL
SHEAR STRESS ON ROTATING BAND (PSI) *10²
BEARING STRESS ON ROTATING BAND (PSI) *10²
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
PROJECTILE POSITION DOWN BARREL (INCHES)
TORQUE
BEARING STRESS
SHEAR STRESS

FIGURE A-13

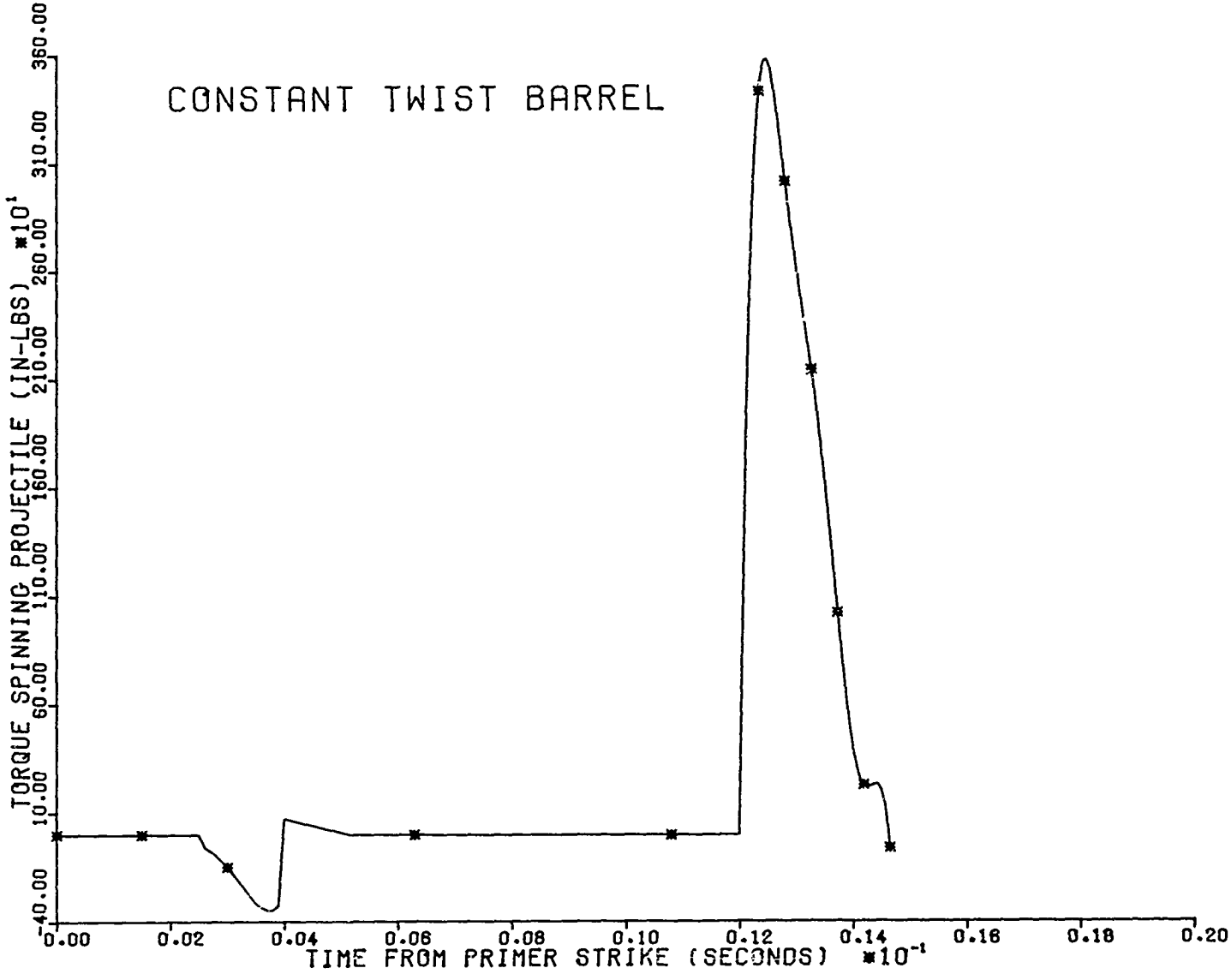
CONSTANT TWIST BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
TIME FROM PRIMER STRIKE (SECONDS) *10⁻¹

FIGURE A-14

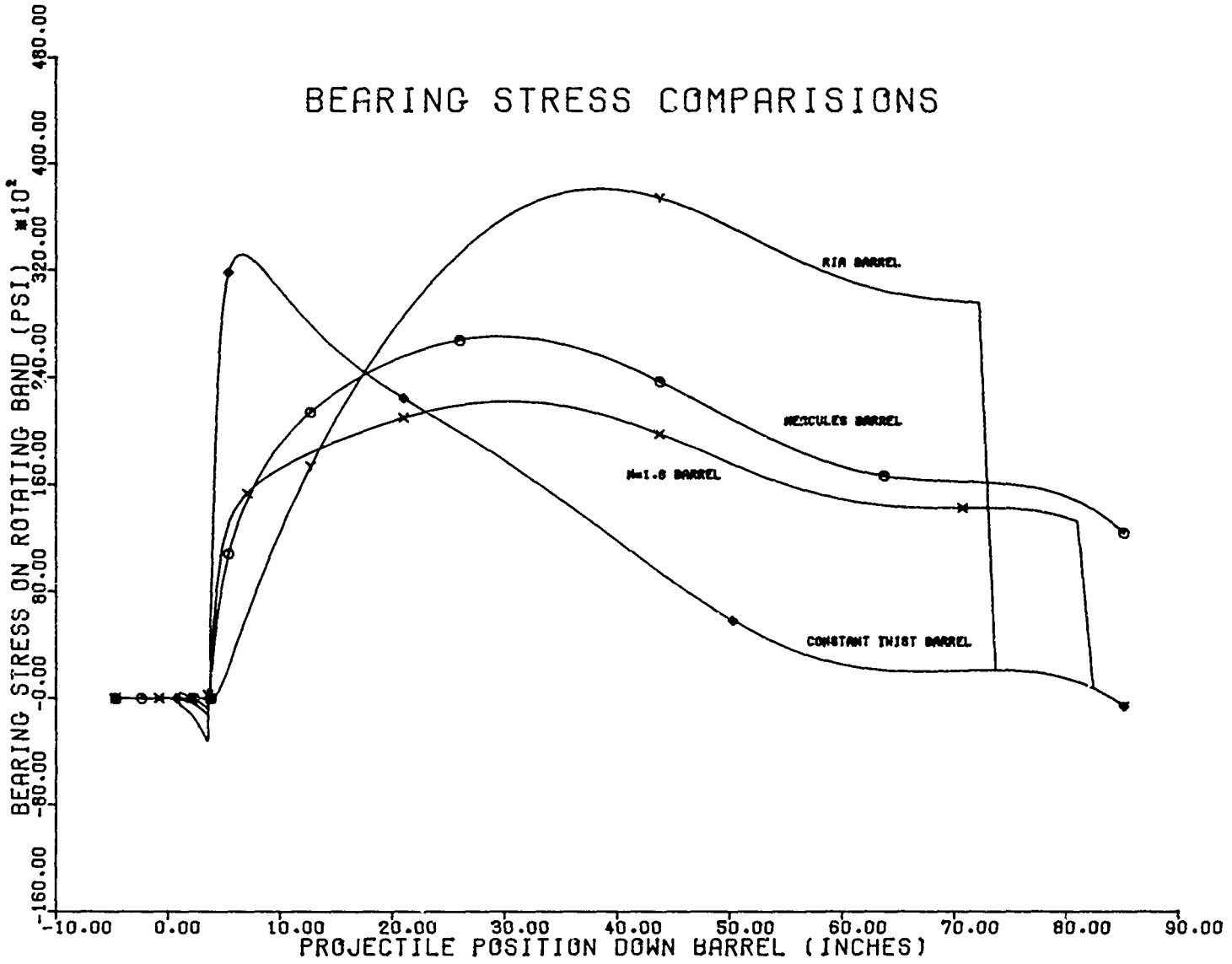
BEARING STRESS COMPARISIONS
BEARING STRESS ON ROTATING BAND (PSI) *10²
480.00
400.00
320.00
240.00
160.00
80.00
-0.00
-80.00
-160.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)
RIA BARREL
HERCULES BARREL
M=1.8 BARREL
CONSTANT TWIST BARREL

FIGURE A-15

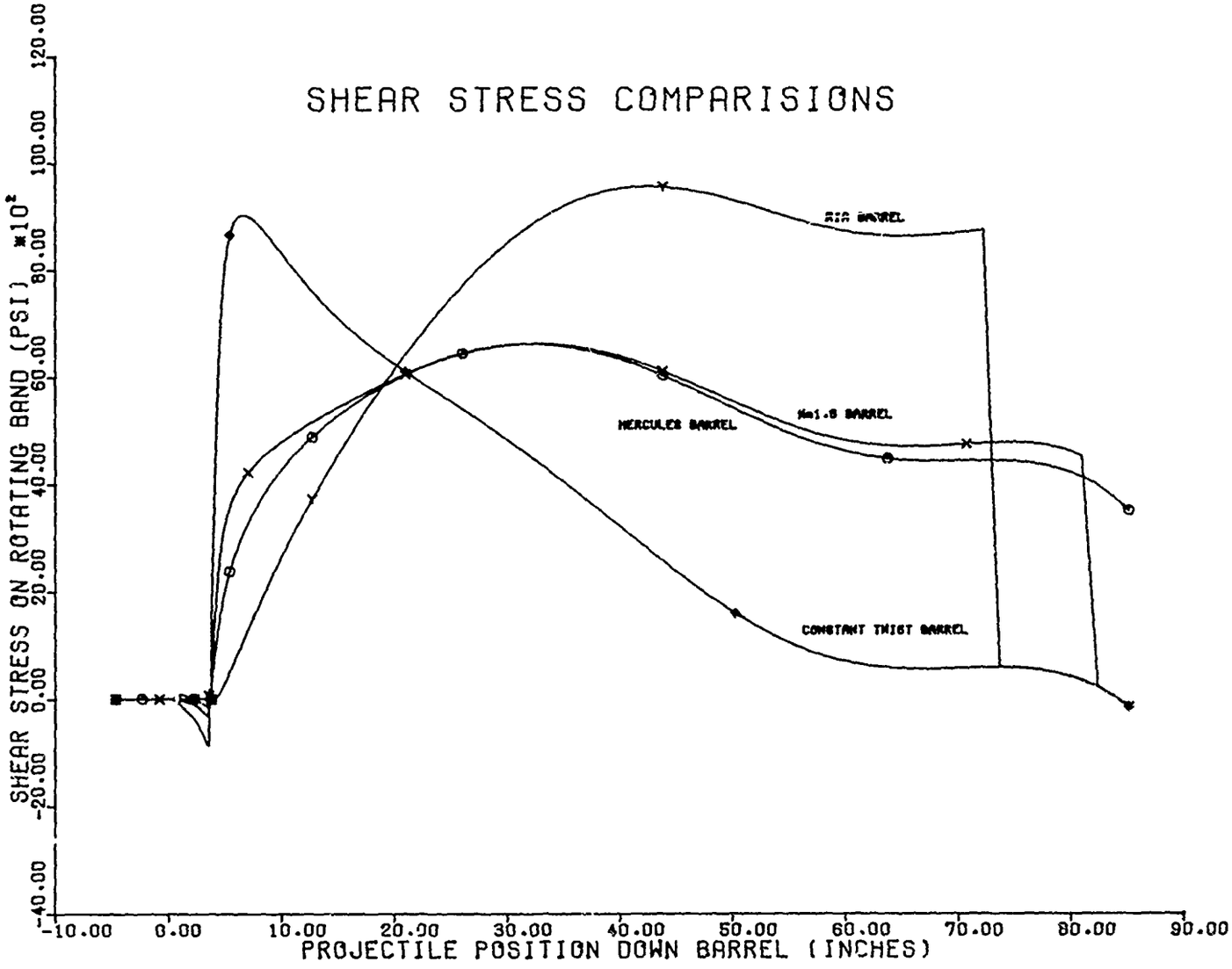
SHEAR STRESS COMPARISIONS
SHEAR STRESS ON ROTATING BAND (PSI) *10²
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
HERCULES BARREL
CONSTANT TWIST BARREL
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)

FIGURE A-16

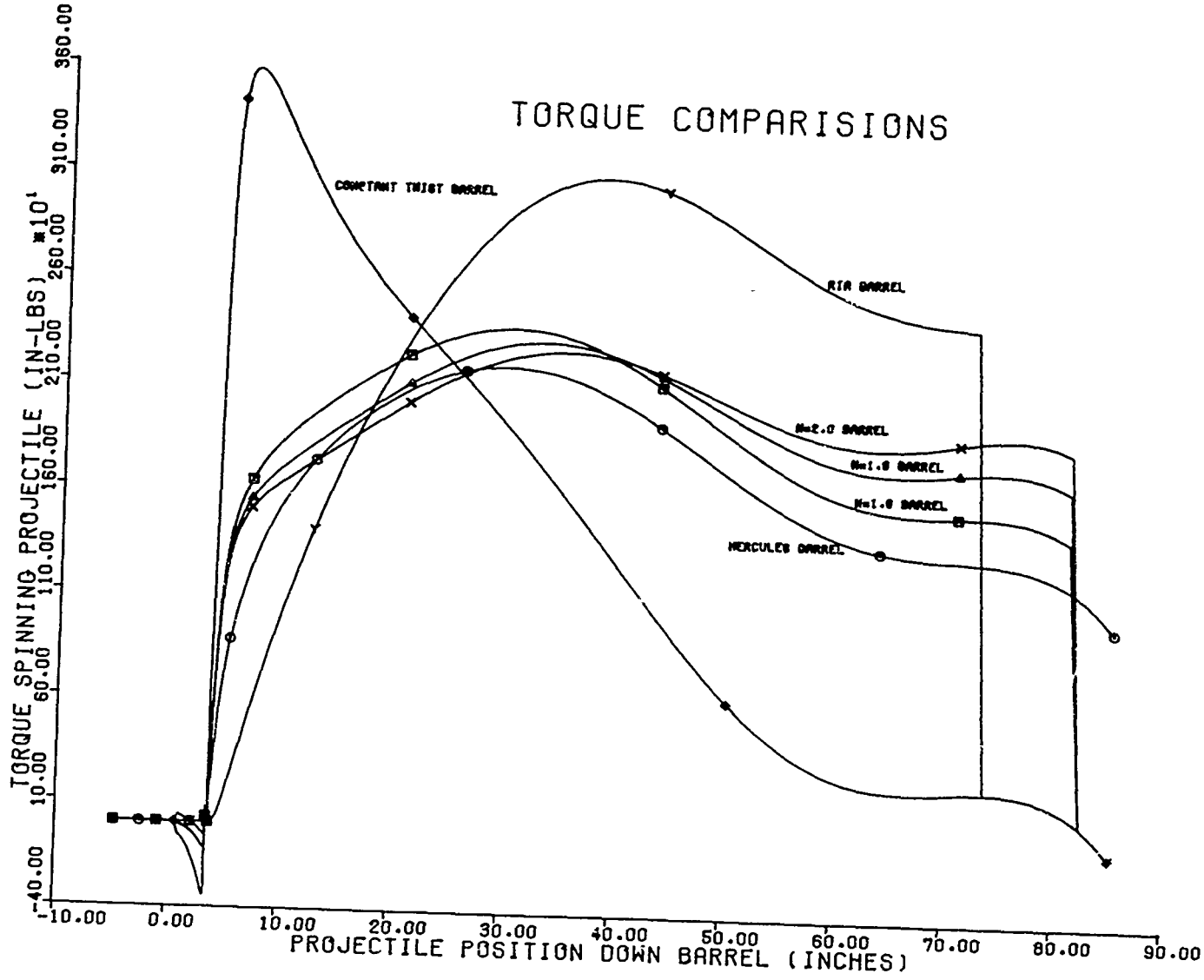
TORQUE COMPARISIONS
CONSTANT TWIST BARREL
RIA BARREL
M=2.0 BARREL
M=1.8 BARREL
M=1.6 BARREL
HERCULES BARREL
TORQUE SPINNING PROJECTILE (IN-LBS) *10¹
-40.00
10.00
60.00
110.00
160.00
210.00
260.00
310.00
360.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
PROJECTILE POSITION DOWN BARREL (INCHES)

FIGURE A-17

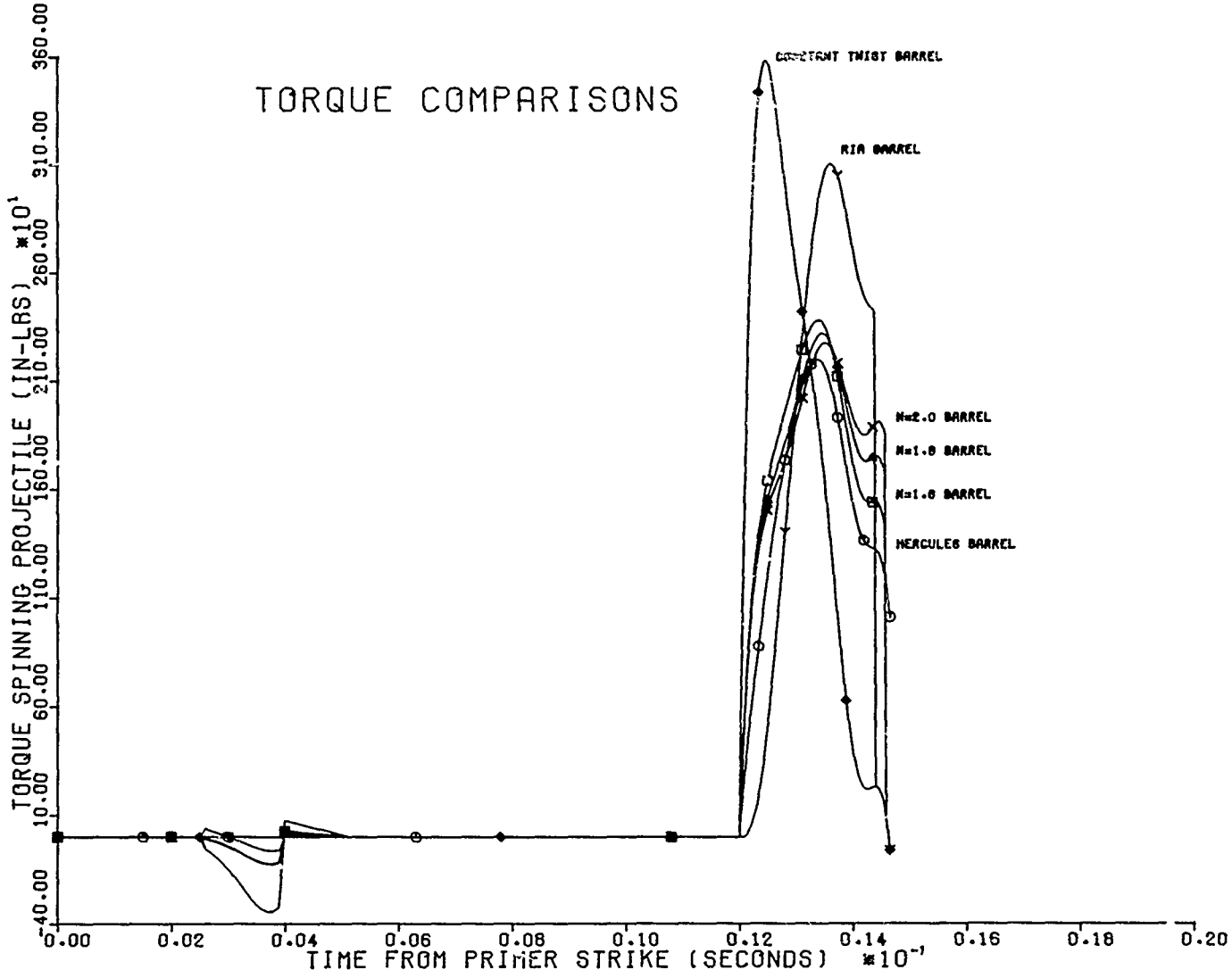

FIGURE A-18

(THE FOLLOWING PAGE IS BLANK)

APPENDIX B

AMCAWS 30 INTERIOR

BALLISTICS LINKING COMPUTER

PROGRAM

```
C*********************************************************************
C*********************************************************************
C*********************************************************************
C*********************************************************************
C*********************************************************************
C      AMCAWS 30MM INTERIOR BALLISTICS LINKING COMPUTER PROGRAM
C              PROGRAM BY MICHAEL H. KANE  (SARRI-LW-A)
C*********************************************************************
C*********************************************************************
C*********************************************************************
C*********************************************************************
C*********************************************************************
C*********************************************************************
C          COEFFICIENTS ARE BASED ON INTERFEROMETER TRACE OF
C                    HERCULES FIRING OF 13 JULY 73
C*********************************************************************
C*********************************************************************
C*********************************************************************
C        SIGNIFICANT FIGURES IN EXCESS OF THE MACHINE ACCURACY
C                      ARE INCLUDED FOR REFERENCE
C*********************************************************************
C*********************************************************************
C*********************************************************************
C*********************************************************************
      REAL TIME(252),X(252), VEL(252),          ACC(252),PRS(252)
      REAL A(11),B(11),P(11)
      REAL XA(11),VVEL(11),AACC(11),PPRS(11)
      A(11)=  -3.8
      A(10)=  -5.686760649 E+03
      A(9)=  -1.678959377 E+07
      A(8)=  -7.015722817 E+10
      A(7)=  -7.574244804 E+13
      A(6)=  -3.999482108 E+16
      A(5)=  -7.535980122 E+18
      A(4)=  -1.371577520 E+21
      A(3)=  -3.863070172 E+23
      A(2)=  -1.558554942 E+26
      A(1)= -4.022193255 E+28
      B(11)=  -1.344604905 E-01
      B(10)=  -4.819073185 E+05
      B(9)=  -7.166819318 E+09
      B(8)=  -8.688883920 E+12
      B(7)=  -2.653064908 E+15
      B(6)=  -2.817450480 E+18
      B(5)=  -2.783677776 E+21
      B(4)=  -7.811766024 E+23
      B(3)=  -3.748423479 E+25
      B(2)=  -5.390354896 E+28
      B(1) = 6.918145456 E+30
      P(11)=  -5.020450541 E+03
      P(10)=  -1.816365791 E+08
      P(9)=  -2.464008533 E+11
      P(8)=  -2.953361257 E+14
```

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```
0030            P(7)=  -4.2534e28 E-17                                  00000430
0031            P(6)=  +3.6e5627735 E-20                                00000440
0032            P(5)=  -1.e9112e+80 E-23                                00000450
0033            P(4)=  +2.+c0000095 E-25                                00000460
0034            P(3)=  -5.0e14e4e0C3 E-27                               00000470
0035            P(2)=  -2.21e3677/e E+30                                00000480
0036            P(1)=  2.12e27741e E+32                                 00000490
0037            DELTA=.0000308                                          00000500
0038            J=0                                                     00000510
0039            CALL PREST=                                             00000520
0040         90 READ(5,100,END=110) AA,BB,CC,DD,EE                      00000530
0041        100 FORMAT(5E16.7)                                          00000540
0042            PUNCH100,AA,BB,CC,DD,EE                                 00000550
0043            WRITE(6,80)AA,BB,CC,DD,EE                               00000560
0044            GO TO 90                                                00000570
0045        110 CONTINUE                                                00000580
0046            JSET=J-1                                                00000590
0047            TE=DELTA
0048            NUMBER=1                                                00000680
0049            N=NUMBER-1                                              00000690
0050            XX(1)=A(1)
0051            VEL(1)=H(1)
0052            ACC(1)=G(1)
0053            PRS(1)=P(1)
0054         10 J=J+1                                                   00000660
0055            T=T+DELTA                                               00000670
0056            DO 15 I=2,N                                             00000730
0057            X(I)=A(I)+T*XX(I-1)                                     00000740
0058            VVEL(I)=H(I)+T*VVEL(I-1)                                00000750
0059            ACC(I)=VVEL(I)+T*ACC(I-1)                               00000760
0060         15 PRS(I)=P(I)+T*PRS(I-1)                                  00000770
0061            ACC(J)=ACC(N)                                           00000780
0062            X(J)=A(NUMBER)+T*XX(N)                                  00000790
0063            VEL(J)=H(NUMBER)+T*VEL(N)                               00000800
0064            PRS(J)=P(NUMBER)+T*PRS(N)                               00000810
0065             IF(X(J).GT.99.0) GO TO 20                              00000820
0066            GO TO 10                                                00000830
0067         20 NSET=J                                                  00000840
0068            TIME(1)=AA-DELTA                                        00000850
0069            DO 120 J=2,NSET                                         00000860
0070        120 TIME(J)=TIME(J-1)+DELTA                                 00000870
0071            N=1                                                     00000880
0072            DO 40 J=1,NSET                                          00000890
              C     WRITE(6,30)N, J,TIME(J), X(J), VEL(J),      ACC(J),PRS(J)  00000900
0073         30 FORMAT(' ', I3,I5,1X,E10.3,4(1X,E10.3))                 00000910
             C*** REMOVE COMMENT DESIGNATORS FROM NEXT TWO CARDS TO GET PUNCHED OUTPU00000920
0074            PUNCH35,TIME(J),X(J),VEL(J),ACC(J),PRS(J)               00000930
0075         35 FORMAT(5E16.7)                                          00000940
0076            WRITE(6,80) TIME(J),X(J),VEL(J),ACC(J),PRS(J)           00000950
0077         80 FORMAT(' ',5E16.7,' **')                                00000960
0078         40 CONTINUE                                                00000970
0079            STOP                                                    00000980
0080            END                                                     00000990
```

```
      SUBROUTINE PRESTP
      REAL POS(50),VEL(50),ACC(50),TIME(50)
      N=9
      REAL PPOS(11),VVEL(11),AACC(11),B(11)
C
C
C***** THIS GENERATES DATA POINTS FOR PRE-STOP SEGMENT ***************
C***** AND DATA POINTS FOR STOP SEGMENT ***************************
      PRS=1000.0
      B(11)= -1.874969   E-01
      B(10)=  6.963141   E+02
      B(9)=  1.257153   E+06
      B(8)=  3.002323   E+08
      B(7)= -3.571477   E+11
      B(6)= -1.876731   E+13
      B(5)=  7.082854   E+16
      B(4)= -1.110843   E+19
      B(3)= -4.728447   E+21
      B(2)= 1.568389  E+24
      B(1)=-1.267303   E+26
      T=-0.0011
      DELTA=0.0001
      PPOS(1)=B(1)
      VVEL(1)=B(1)
      AACC(1)=B(1)
      DO 10 JI=1,50
      T=T+DELTA
      TIME(JI)=T
      DO 5 I=2,N
      PPOS(I)=B(I)+T*PPOS(I-1)
      VVEL(I)=PPOS(I)+T*VVEL(I-1)
      AACC(I)=VVEL(I)+T*AACC(I-1)
    5 CONTINUE
      ACC(JI)=AACC(9)* 2.0
      PPOS(10)=B(10)+T*PPOS(9)
      VEL(JI)=PPOS(10)+T*VVEL(9)
      POS(JI)=B(11)+T*PPOS(10)
   10 CONTINUE
      DO 70 JI=1,50
      POS(JI)=POS(JI)- 4.4
      VEL(JI)=VEL(JI)/12.0
      ACC(JI)=ACC(JI)/12.0
   35 FORMAT(5(E16.7))
   70 CONTINUE
      DO 23 JI=2,50
   23 ACC(JI)=(VEL(JI)-VEL(JI-1))/0.0001
      ACC(1)=135000.
      DO 31 JI=1,50
      TIME(JI)=TIME(JI)+0.0004
   31 CONTINUE
      TIME(7)=0.0
      VEL(7)=0.00
      ACC(7)=48800.0
```

```
      VEL(47)=0.00                                                      00000540
      ACC(47)=50000.0                                                   00000550
      M=5                                                               00000560
      DO 32 JI=7,47                                                     00000570
      PUNCH35,TIME(JI),POS(JI),VEL(JI),ACC(JI),PRS                      00000580
      WRITE(6,80)TIME(JI),POS(JI),VEL(JI),ACC(JI),PRS                   00000590
   80 FORMAT(' ', 5E16.7, ' ', *1)                                      00000600
   32 CONTINUE                                                          00000610
      RETURN                                                            00000620
      END                                                               00000630
```

0.0	-0.4692418E+01	0.0	0.4880000E+05	0.1000000E+04	*
0.1000003E-03	-0.4693966E+01	0.4884786E+01	0.1175702E+06	0.1000000E+04	*
0.2000003E-03	-0.4679356E+01	0.1998500E+02	0.1510021E+06	0.1000000E+04	*
0.3000002E-03	-0.4644872E+01	0.3790884E+02	0.1792384E+06	0.1000000E+04	*
0.4000003E-03	-0.4587496E+01	0.5802625E+02	0.2011740E+06	0.1000000E+04	*
0.5000001E-03	-0.4505009E+01	0.7964322E+02	0.2161697E+06	0.1000000E+04	*
0.6000001E-03	-0.4396038E+01	0.1020463E+03	0.2240306E+06	0.1000000E+04	*
0.7000002E-03	-0.4260061E+01	0.1245421E+03	0.2249585E+06	0.1000000E+04	*
0.8000000E-03	-0.4097357E+01	0.1464913E+03	0.2194916E+06	0.1000000E+04	*
0.8999999E-03	-0.3908926E+01	0.1673353E+03	0.2084404E+06	0.1000000E+04	*
0.9999997E-03	-0.3696380E+01	0.1866162E+03	0.1928084E+06	0.1000000E+04	*
0.1100000E-02	-0.3461813E+01	0.2039879E+03	0.1737176E+06	0.1000000E+04	*
0.1199999E-02	-0.3207667E+01	0.2192220E+03	0.1523407E+06	0.1000000E+04	*
0.1299999E-02	-0.2936584E+01	0.2322044E+03	0.1298237E+06	0.1000000E+04	*
0.1399999E-02	-0.2651283E+01	0.2429266E+03	0.1072226E+06	0.1000000E+04	*
0.1499999E-02	-0.2354432E+01	0.2514726E+03	0.8545975E+05	0.1000000E+04	*
0.1599999E-02	-0.2048557E+01	0.2579990E+03	0.6526413E+05	0.1000000E+04	*
0.1699999E-02	-0.1735960E+01	0.2627141E+03	0.4715088E+05	0.1000000E+04	*
0.1799998E-02	-0.1418674E+01	0.2658545E+03	0.3140381E+05	0.1000000E+04	*
0.1899998E-02	-0.1098444E+01	0.2676604E+03	0.1805908E+05	0.1000000E+04	*
0.1999998E-02	-0.7767363E+00	0.2683513E+03	0.6909180E+04	0.1000000E+04	*
0.2099998E-02	-0.4547749E+00	0.2681067E+03	-0.2446289E+04	0.1000000E+04	*
0.2199998E-02	-0.1336050E+00	0.2670457E+03	-0.1061035E+05	0.1000000E+04	*
0.2299997E-02	0.1858282E+00	0.2652131E+03	-0.1832520E+05	0.1000000E+04	*
0.2399997E-02	0.5025854E+00	0.2625737E+03	-0.2639404E+05	0.1000000E+04	*
0.2499997E-02	0.8156328E+00	0.2590068E+03	-0.3566895E+05	0.1000000E+04	*
0.2599997E-02	0.1123751E+01	0.2543141E+03	-0.4692688E+05	0.1000000E+04	*
0.2699997E-02	0.1425431E+01	0.2482289E+03	-0.6085266E+05	0.1000000E+04	*
0.2799997E-02	0.1718811E+01	0.2404353E+03	-0.7793544E+05	0.1000000E+04	*
0.2899996E-02	0.2001658E+01	0.2306012E+03	-0.9834119E+05	0.1000000E+04	*
0.2999996E-02	0.2271308E+01	0.2184000E+03	-0.1220122E+06	0.1000000E+04	*
0.3099996E-02	0.2524759E+01	0.2035583E+03	-0.1484164E+06	0.1000000E+04	*
0.3199996E-02	0.2758718E+01	0.1858933E+03	-0.1766508E+06	0.1000000E+04	*
0.3299996E-02	0.2969764E+01	0.1653604E+03	-0.2053291E+06	0.1000000E+04	*
0.3399996E-02	0.3154484E+01	0.1420856E+03	-0.2327471E+06	0.1000000E+04	*
0.3499995E-02	0.3309816E+01	0.1164272E+03	-0.2565849E+06	0.1000000E+04	*
0.3599995E-02	0.3433199E+01	0.8898361E+02	-0.2744354E+06	0.1000000E+04	*
0.3699995E-02	0.3523000E+01	0.6063272E+02	-0.2835089E+06	0.1000000E+04	*
0.3799995E-02	0.3578825E+01	0.3253175E+02	-0.2810097E+06	0.1000000E+04	*
0.3899995E-02	0.3601729E+01	0.6086893E+01	-0.2644486E+06	0.1000000E+04	*
0.3999993E-02	0.3594741E+01	0.0	0.6000000E+05	0.1000000E+04	*
0.5150001E-02	0.3800000E+01	0.0	0.0	0.4000000E+03	*
0.5399998E-02	0.3800000E+01	0.0	0.0	0.4000000E+03	*
0.5700000E-02	0.3800000E+01	0.0	0.0	0.4000000E+03	*
0.6000001E-02	0.3800000E+01	0.0	0.0	0.4000000E+03	*
0.6299999E-02	0.3800000E+01	0.0	0.0	0.4000000E+03	*
0.6600000E-02	0.3800000E+01	0.0	0.0	0.4000000E+03	*
0.6900001E-02	0.3800000E+01	0.0	0.0	0.5550000E+03	*
0.7199999E-02	0.3800000E+01	0.0	0.0	0.7100000E+03	*
0.7500000E-02	0.3800000E+01	0.0	0.0	0.8650000E+03	*
0.7800002E-02	0.3800000E+01	0.0	0.0	0.1020000E+04	*
0.8099999E-02	0.3800000E+01	0.0	0.0	0.1175000E+04	*
0.8400001E-02	0.3800000E+01	0.0	0.0	0.1330000E+04	*
0.8699998E-02	0.3800000E+01	0.0	0.0	0.1485000E+04	*
0.9000000E-02	0.3800000E+01	0.0	0.0	0.1640000E+04	*
0.9300001E-02	0.3800000E+01	0.0	0.0	0.1795000E+04	*
0.9599999E-02	0.3800000E+01	0.0	0.0	0.1950000E+04	*
0.9900000E-02	0.3800000E+01	0.0	0.0	0.2150000E+04	*
0.1020000E-01	0.3800000E+01	0.0	0.0	0.2260000E+04	*
				0.2415000E+04	*

0.1050000E-01	0.3800000E+01	0.0	0.0	0.2570000E+04	*
0.1080000E-01	0.3800000E+01	0.0	0.0	0.2725000E+04	*
0.1110000E-01	0.3800000E+01	0.0	0.0	0.2880000E+04	*
0.1140000E-01	0.3800000E+01	0.0	0.0	0.3035000E+04	*
0.1180000E-01	0.3800000E+01	0.0	0.0	0.3190000E+04	*
0.1200000E-01	0.3800000E+01	0.0	0.0	0.3500000E+04	*
0.1203080E-01	0.3799999E+01	0.1344604E+00	0.4819073E+06	0.5020449E+04	*
0.1206159E-01	0.3961206E+01	0.2152451E+02	0.8989772E+06	0.1038937E+05	*
0.1209239E-01	0.4101937E+01	0.5502438E+02	0.1268615E+07	0.1533757E+05	*
0.1212319E-01	0.4232200E+01	0.9920726E+02	0.1593072E+07	0.1990467E+05	*
0.1215398E-01	0.4360620E+01	0.1527188E+03	0.1874798E+07	0.2412342E+05	*
0.1218478E-01	0.4494570E+01	0.2142828E+03	0.2116397E+07	0.2802072E+05	*
0.1221558E-01	0.4640272E+01	0.2827046E+03	0.2320582E+07	0.3161852E+05	*
0.1224637E-01	0.4802919E+01	0.3568745E+03	0.2490135E+07	0.3493459E+05	*
0.1227717E-01	0.4986775E+01	0.4357698E+03	0.2627874E+07	0.3798330E+05	*
0.1230797E-01	0.5195277E+01	0.5184529E+03	0.2736612E+07	0.4077628E+05	*
0.1233876E-01	0.5431127E+01	0.6040750E+03	0.2819136E+07	0.4332297E+05	*
0.1236956E-01	0.5696382E+01	0.6918694E+03	0.2878166E+07	0.4563117E+05	*
0.1240036E-01	0.5992535E+01	0.7811545E+03	0.2916349E+07	0.4770746E+05	*
0.1243116E-01	0.6320602E+01	0.8713274E+03	0.2936224E+07	0.4955760E+05	*
0.1246195E-01	0.6681172E+01	0.9618618E+03	0.2940210E+07	0.5118689E+05	*
0.1249275E-01	0.7074505E+01	0.1052303E+04	0.2930590E+07	0.5260045E+05	*
0.1252355E-01	0.7500561E+01	0.1142267E+04	0.2909499E+07	0.5380338E+05	*
0.1255434E-01	0.7959072E+01	0.1231430E+04	0.2878917E+07	0.5480102E+05	*
0.1258514E-01	0.8449588E+01	0.1319528E+04	0.2840656E+07	0.5559911E+05	*
0.1261594E-01	0.8971533E+01	0.1406351E+04	0.2796359E+07	0.5620381E+05	*
0.1264673E-01	0.9524216E+01	0.1491736E+04	0.2747501E+07	0.5662186E+05	*
0.1267753E-01	0.1010690E+02	0.1575563E+04	0.2695381E+07	0.5686059E+05	*
0.1270833E-01	0.1071880E+02	0.1657748E+04	0.2641126E+07	0.5692786E+05	*
0.1273913E-01	0.1135914E+02	0.1738244E+04	0.2585708E+07	0.5683226E+05	*
0.1276992E-01	0.1202714E+02	0.1817023E+04	0.2529918E+07	0.5658280E+05	*
0.1280072E-01	0.1272206E+02	0.1894088E+04	0.2474411E+07	0.5618907E+05	*
0.1283152E-01	0.1344320E+02	0.1969455E+04	0.2419687E+07	0.5566116E+05	*
0.1286231E-01	0.1418989E+02	0.2043152E+04	0.2366105E+07	0.5500944E+05	*
0.1289311E-01	0.1496155E+02	0.2115219E+04	0.2313903E+07	0.5424465E+05	*
0.1292391E-01	0.1575764E+02	0.2185704E+04	0.2263211E+07	0.5337769E+05	*
0.1295470E-01	0.1657768E+02	0.2254649E+04	0.2214029E+07	0.5241959E+05	*
0.1298550E-01	0.1742123E+02	0.2322100E+04	0.2166286E+07	0.5138140E+05	*
0.1301630E+01	0.1828795E+02	0.2388104E+04	0.2119839E+07	0.5027411E+05	*
0.1304710E-01	0.1917749E+02	0.2452693E+04	0.2074456E+07	0.4910835E+05	*
0.1307789E-01	0.2008952E+02	0.2515899E+04	0.2029870E+07	0.4789480E+05	*
0.1310869E-01	0.2102382E+02	0.2577738E+04	0.1985763E+07	0.4664364E+05	*
0.1313949E-01	0.2198012E+02	0.2638219E+04	0.1941802E+07	0.4536434E+05	*
0.1317028E-01	0.2295816E+02	0.2697349E+04	0.1897641E+07	0.4406619E+05	*
0.1320108E-01	0.2395769E+02	0.2755114E+04	0.1852922E+07	0.4275809E+05	*
0.1323188E-01	0.2497838E+02	0.2811476E+04	0.1807270E+07	0.4144757E+05	*
0.1326267E-01	0.2601999E+02	0.2866426E+04	0.1760413E+07	0.4014224E+05	*
0.1329347E-01	0.2708218E+02	0.2919904E+04	0.1712026E+07	0.3884877E+05	*
0.1332427E-01	0.2816451E+02	0.2971864E+04	0.1661856E+07	0.3757268E+05	*
0.1335507E-01	0.2926649E+02	0.3022250E+04	0.1609709E+07	0.3631930E+05	*
0.1338586E-01	0.3038776E+02	0.3071003E+04	0.1555427E+07	0.3509323E+05	*
0.1341666E-01	0.3152760E+02	0.3118045E+04	0.1498911E+07	0.3389712E+05	*
0.1344746E-01	0.3268544E+02	0.3163316E+04	0.1440146E+07	0.3273487E+05	*
0.1347825E-01	0.3386050E+02	0.3206731E+04	0.1379142E+07	0.3160873E+05	*
0.1350905E-01	0.3505208E+02	0.3248242E+04	0.1316024E+07	0.3051961E+05	*
0.1353985E-01	0.3625935E+02	0.3287786E+04	0.1251002E+07	0.2946870E+05	*
0.1357064E-01	0.3748132E+02	0.3325292E+04	0.1184257E+07	0.2845565E+05	*
0.1360144E-01	0.3871700E+02	0.3360707E+04	0.1116108E+07	0.2748131E+05	*
0.1363224E-01	0.3996562E+02	0.3394032E+04	0.1046986E+07	0.2654422E+05	*
0.1366303E-01	0.4122600E+02	0.3425210E+04	0.9772770E+06	0.2564523E+05	*

0.1369383E-01	0.4249721E+02	0.3454217E+04	0.9074120E+06	0.2478049E+05	*
0.1372463E-01	0.4377829E+02	0.3481105E+04	0.8380000E+06	0.2395120E+05	*
0.1375543E-01	0.4506813E+02	0.3508857E+04	0.7695140E+06	0.2315179E+05	*
0.1378622E-01	0.4636592E+02	0.3528525E+04	0.7025470E+06	0.2238451E+05	*
0.1381702E-01	0.4767075E+02	0.3549141E+04	0.6376370E+06	0.2164789E+05	*
0.1384782E-01	0.4898189E+02	0.3567828E+04	0.5754590E+06	0.2093587E+05	*
0.1387861E-01	0.5029884E+02	0.3584643E+04	0.5164910E+06	0.2025285E+05	*
0.1390941E-01	0.5162083E+02	0.3599683E+04	0.4612520E+06	0.1959304E+05	*
0.1394021E-01	0.5294777E+02	0.3613098E+04	0.4102530E+	0.1895677E+05	*
0.1397100E-01	0.5427902E+02	0.3625008E+04	0.3639290E+06	0.1834476E+05	*
0.1400180E-01	0.5561505E+02	0.3635566E+04	0.3225790E+06	0.1775431E+05	*
0.1403260E-01	0.5695564E+02	0.3644909E+04	0.2864320E+06	0.1718288E+05	*
0.1406340E-01	0.5830157E+02	0.3653277E+04	0.2558550E+06	0.1664011E+05	*
0.1409419E-01	0.5965315E+02	0.3660742E	0.2306410E+06	0.1611369E+05	*
0.1412499E-01	0.6101120E+02	0.3667530E+	0.2108450E+06	0.1561445E+05	*
0.1415579E-01	0.6237605E+02	0.3673773E+04	0.1961700E+06	0.1513847E+05	*
0.1418658E-01	0.6374960E+02	0.3679662E+04	0.1863530E+06	0.1467940E+05	*
0.1421738E-01	0.6513191E+02	0.3685265E+04	0.1807040E+06	0.1425851E+05	*
0.1424818E-01	0.6652463E+02	0.3690834E+04	0.1788660E+06	0.1385346E+05	*
0.1427897E-01	0.6792841E+02	0.3696337E+04	0.1796890E+06	0.1347916E+05	*
0.1430977E-01	0.6934346E+02	0.3701865E+04	0.1821980E+06	0.1312322E+05	*
0.1434057E-01	0.7077135E+02	0.3707638E+04	0.1858050E+06	0.1279090E+05	*
0.1437137E-01	0.7221117E+02	0.3713393E+04	0.1885410E+06	0.1247523E+05	*
0.1440216E-01	0.7366190E+02	0.3719240E+04	0.1894490E+06	0.1219534E+05	*
0.1443296E-01	0.7512219E+02	0.3725003E+04	0.1868480E+06	0.1191098E+05	*
0.1446376E-01	0.7658949E+02	0.3730676E+04	0.1794280E+06	0.1163548E+05	*
0.1449455E-01	0.7805966E+02	0.3735961E+04	0.1654230E+06	0.1134989E+05	*
0.1452535E-01	0.7952635E+02	0.3740727E+04	0.1434280E+06	0.1106421E+05	*
0.1455615E-01	0.8098186E+02	0.3744745E+04	0.1121820E+06	0.1073695E+05	*
0.1458694E-01	0.8241580E+02	0.3747571E+04	0.7006200E+05	0.1037077E+05	*
0.1461774E-01	0.8381381E+02	0.3748902E+04	0.1592000E+05	0.9923262E+04	*
0.1464854E-01	0.8515953E+02	0.3748406E+04	-0.5078400E+05	0.9377691E+04	*